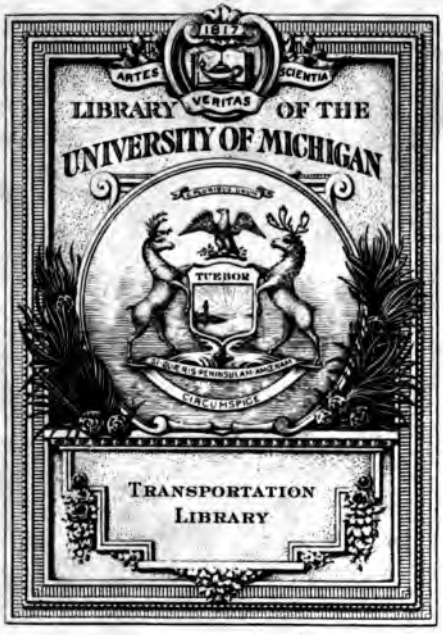
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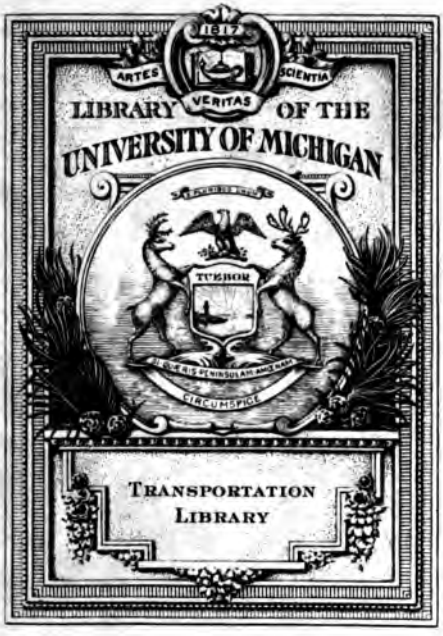
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MANUAL FOR RESIDENT ENGINEERS.

CONTAINING GENERAL INFORMATION ON CONSTRUCTION.

BY
F. A. MOLITOR
AND
E. J. BEARD,
Members of the American Society of Civil Engineers.

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SECOND THOUSAND.

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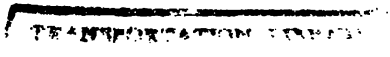


PREFACE.

DURING the construction of the Choctaw, Oklahoma & Gulf Railroad Company's line across the State of Arkansas in 1899, the first fifty pages of this book were written by the authors and published in blue-print form as "Instructions" to their resident engineers, with a view of obtaining uniformity of method in both work and results. The note-books, estimates, and construction profiles made by the various resident engineers and filed in the general office on completion of the work were alike and of the standard form and stood the most searching examination in some litigation that followed the construction of the line. When the Choctaw, Oklahoma & Gulf Railroad Company, in 1901, entered upon some five hundred miles of extensions and branches separated from one another, making personal supervision difficult and slow, the authors revised the body of the book, and also the standard specifications of the company, which, together with the tables of level cuttings, were added to the original instructions and published in book form for the railroad company's use, with the result that each of the fifty or more resident engineers employed during the year 1901 were able, without verbal explanations and instructions, to comply with the standards required.

The book, during its three years of private circulation, was found to have attracted the attention of many engineers, and as no pocket-book or manual bearing upon the particular field covered by the original "Instructions" has been published heretofore, the authors have decided to present to the profession generally, and to the younger members particularly, the "Manual," with the hope that it may be as successful in standardizing and simplifying the work of resident engineers throughout the country as it has been in the instance of one railroad.

F. A. M.
E. J. B.

JAN. 1903.

MANUAL

FOR

RESIDENT ENGINEERS.

CONTAINING GENERAL INFORMATION ON CONSTRUCTION.

Duties of Resident Engineers.

1. Ten miles of construction work will usually be allotted to each Resident Engineer, on which portion he will perform all instrument work required to enable the contractor to rapidly and intelligently carry on the work, and especially see that the contractors fully comply with the specifications for all clearing, grading, pile and trestle bridging, and perform such other work as may be assigned him. The Resident Engineer will make up monthly and final estimate of all work done on the residency, performed under the general contract, in accordance with paragraphs 16 and 63.

The Resident Engineers will fully inform themselves of the scope, true intent and meaning of the specifications and contract, and be fully prepared to decide

promptly and intelligently on any question raised, excepting where the contract requires the Chief Engineer to make a decision.

Any Engineer assigned to special duties on any residency must be given every assistance by the Resident Engineer, any friction between employees being prejudicial to the Company's best interests.

Prompt and exact compliance with all the instructions contained herein, or in any circular issued heretofore or hereafter, will be required.

Resident Engineers in their dealings with the contractors are expected to follow a courteous, business-like and ethical course; to recollect that it is the contractors' business to make all the money possible. Resident Engineers are not on the work to prevent this, but to see that the contractors perform their work in strict accordance with the specifications, plans and contract.

To Whom Report.

2. The Resident Engineer will report directly to the Division Engineer, if there be one, otherwise to the Principal Assistant Engineer.

Supplies.

3. Upon appointment, Resident Engineers will obtain by requisition, through their immediate superior, the following supplies, which supply may be maintained through future requisitions.

LIST OF SUPPLIES.

1 Transit.
1 Level.
1 100′ Chain Roe pattern.
1 50′ Chesterman metallic tape
2 Chesterman tape fillers.
1 Self-reading level rod.
2 Transit rods.
1 Ax.
1 Package blue keil.
6 Blotters.
1 lb. Tacks.
2 Transit books.
4 Slope stake books.
1 Cross section plat book.
2 Level books.
3 HHHHHH pencils.
6 HHH pencils.
6 No. 3 pencils.
3 Penholders.
2 Pencil rubber erasers.
24 Estimate sheets.
12 Pay rolls.
12 Scratch pads.
2 Pads letter heads.
50 Large envelopes.
100 Small envelopes.
12 No. 303 pens.
25 Assorted writing pens.
1 Bottle of writing fluid.
1 Bottle Higgins' black ink.
1 Bottle Higgins' blue ink.
1 Bottle Higgins' red ink.
1 Box assorted rubber bands.
1 Copy specifications and contract.
5 Yards duplex manilla paper.
5 Yards profile paper, plate A.
5 Yards profile tracing paper, plate A.
5 Yards tracing cloth.
5 Yards cross section paper, tenths.
Progress water colors.

Size of Party.

4. Resident Engineers will, as a rule, be allowed a rodman and tapeman, and when necessary a team with driver. The rodman must be capable of handling instruments and cross sectioning, the tapeman capable

of handling the rod. The teamster is to make one of the party when in the field.

Post Office, Express, Telephone, and Telegraph Address.

5. Resident Engineers, upon arrival on their residency, will immediately notify the Chief Engineer's office, Principal Assistant Engineer's office and Division Engineer's office, of their post office, express, telephone and telegraph address. In conducting correspondence they will comply with instructions contained in circular No. 4.

Field Profile and Books.

6. Resident Engineers will obtain the necessary data to enable the making up at once, on plate A profile paper, of a field profile similar in every respect to that described in section 64 for the final profile, showing particularly in pencil the approximate quantities and contemplated overhaul.

7. They will keep a transit book, field cross section book, plat cross section book, bridge book, pile recorder's book and diary. A title must be written on the fly leaf of each book, giving the residency number, resident's name, post office address, with a brief statement of what the book is used for, similar in form to the following:

RESIDENCY NO. 2.
MISCELLANEOUS SURVEYS,
E. W. WELLS, Resident Engineer,
P. O., ROLAND, ARK.

This title must be placed on the fly leaf and in no case on the outside of cover, which will be left unmarked except for a small number, which may be placed if desired, for the Resident Engineer's convenience, in the right hand upper corner of the cover. Each leaf must be numbered or paged, dating the beginning and ending of each day's entries, carefully indexing on pages in the front of the book each separate piece of work. All books which are in constant use should be covered. Indexing and paging should be done as the work is performed. A field entry of notes on paper or in memorandum books, intended to be transferred later to the proper book by the Resident Engineer or his subordinates, will not be permitted.

This general form of lettering, indexing, paging, etc., is to be followed with all books used by the Resident Engineer, including the final estimate book.

8. In the transit book should be kept all alignment notes, reference points, land and other surveys, together with all level notes, which may be taken in connection with any survey, to the end that complete notes of every kind, of any small pieces of work, may be contained entirely in one book.

9. In the field, all cross sections should be entered as taken, in the standard form of Cross Section book. If the cross sectioning cannot be carried continuously across a residency, the entries must be made continuously, beginning at the top of the page, leaving at least two or more blank leaves at the end of each mile, to be used for the summary.

Each piece of cross sectioning should be carefully indexed, station to station. At the end of each break

in the cross sectioning, note the page on which the continuation will be found, and on such page refer to the page where the break occurs.

In case of revision, notes previously taken should not be erased, but crossed out with diagonal pencil lines, noting the page and book where the notes of revision are entered.

At the end of each mile, the names of all the grading and clearing contractors engaged on such mile should be given, noting the beginning and ending stations of their work, together with the date they began and completed their work.

10. On a scale of ten feet to one inch, plat all excavation cross sections as taken. Each day's work to be platted and the quantities calculated the same day as made, with the total end area of each cross section inked in. On the excavation area, note the classification lines as they develop during the progress of the work. This book should also contain the monthly estimates of grading, with the area excavated each month colored on each cross section in the progress color designated to be used for the month the work was performed.

11. In standard field books, the notes pertaining to bridges, culverts and other structures required for drainage, should be entered. This field book will be called the Bridge Book.

On the left hand page all bills of timber, piling and quantities are to be entered, and on the right hand page a sketch of the structure, showing in the case of pile bridges, a ravine section, the kind of material penetrated with penetration of piles, similar in outline to standard ravine section. In cases of masonry

culverts and other masonry structures, sufficient dimensions must be shown to enable the quantities to be checked. In all cases care must be taken to show the nature and kind of material the structure is founded upon; giving the quantities, classification and disposition of the material excavated from foundation pits.

Under each structure enter the date work was commenced and the structure completed, the name of the sub-contractor actually performing the work, and that of the inspector.

The bridge book to be finished as indicated by section No. 63, and to be returned as a final estimate.

12. The Resident Engineer's Pile Recorder will keep a record of each pile driven in a standard level book, as shown on the sample page, plate I.

The bents of each bridge will be numbered consecutively, the bank bent toward Memphis being numbered 1, and each pile in each bent lettered A, B, C, D, from left to right, when looking from Memphis.

The record will show on the left hand page length of pile billed, length put in leads, depth of penetration below the surface of the ground, the total penetration of each pile under the last five blows of the hammer; together with the average fall of the hammer while making the last five blows, with the kind of pile. On the right hand page all remarks bearing on the work should be entered, such, for example, as one end of a condemned pile being cut off, leaving it still long enough for use, thus explaining the difference in length between the length billed and the length put in the lead; or if a pile of the length billed should not be on the ground and a shorter length is used, being sufficient

Bridge No. 5638.
45 ft. Pile and Frame Bridge.

Bents.	Length Bents.	Length Pile in Leads	Penetration	Last 5 Blows	
				Penetration	Average fall of Hammer
Bent 1.	Sta. 124+52				
A	18	18	16	4	28
B	18	18	16	4.	28
C	18	16	14	5	30
D	18	18	16	4	28
Bent 2	Sta. 124+66.5				
A	24	24	12	1	25
B	24	24	10.5	2	"
C	24	24	11	1	"
D	24	24	11.5	1	25
Bent 3	Sta. 124+81.2				
A	22	22	12	1	25
B	22	22	12.5	1	25
C	22	22	13	1	25
D	22	22	12	1	25
Bent 4	Sta. 124+96				
A	20	20	17	1	28
B	20	20	17	1	28
C	20	18	16.5	2	28
D	20	20	17	1	28

PLATE I.

Pile Length	Material	
	Oak.	June 6 - 7 A.M.
18	"	
18	"	
18	"	This pile C undersized at small end.
18	"	2 ft condemned and cut off.
24	"	
24	"	
20 24	"	Pile C broke after striking rock
24	"	insufficiently shot, ordered hole reshot
		and driven a 20 ft pile. 18 ft broken pile used
22	"	for bent 4.
22	"	Pile holes twenty 2 over 3 shot
22	"	8 hole shot
22	"	reshot 9 "
20	"	
20	"	
-		Pay for in C bent 2.
20	"	Completed June 6 - 2 P.M.
		A..... B.....

Correct.
A.E.W.....
Res. Engr.

McGinty & Klein Inspectors
Sub Cont. for Driving
Jos B..... Foreman driver.

on account of the material penetrated offering a greater resistance than originally estimated.

It will be the Resident Engineer's duty to see that the Pile Record Book is kept by the Recorder in the manner above explained.

13. The Resident Engineer will keep a diary, entering briefly all instructions given to contractors, date that each contractor began and completed his work, the date of beginning and completion of all openings and important pieces of work; carefully keeping in it notes regarding classified material, the manner in which contractors handle the various kinds of material, and any other matter that may be an aid or guide in making the final classification and estimate.

Weekly Progress Report.

14. Every Sunday the Resident Engineer will mail to the Chief Engineer and to the Principal Assistant Engineer, a progress report on form No..... giving the average number of men and teams engaged per day, during the week, on each section. Under "remarks," briefly stating the progress of work on each mile, the location of pile driver, and station of end of track.

Monthly Pay Rolls, Expense Accounts and Estimates.

15. On the first day of each month, all pay rolls, expense accounts, approximate monthly estimates, progress profiles, bills, etc., must be mailed to such office as directed.

When any employee is transferred during the month

from one party to another, the Resident Engineer must give such an employee a letter, stating therein the amount of time due him on account of service on his party, and the Resident Engineer to whom the transfer is made will allow time for making the trip by the shortest route; should such employee be again transferred during the same month, his time is to be noted on the original transfer letter sent to the next Engineer. Such transfer letter to be attached to the pay roll turned in by the Resident Engineer on whose roll his name last appears.

Approximate Monthly Estimates.

16. Triplicate approximate estimates (Form C-4), showing the total amount of work performed from the beginning of the work to the end of the month for which the estimate was rendered, should be made, entering the quantities in each cut and fill to the nearest one hundred cubic yards. In timber structures, to the nearest one thousand feet B. M. In masonry, to the nearest cubic yard. The first column should contain the names of the sub-contractors.

One or more miles may be put on a sheet, but each mile must show complete on one sheet. Showing the total of each item of quantities in each mile in *red* figures; on the next line, showing total of each item of quantities, as estimated to the end of the preceding month, in *black* figures, which quantities deducted from the first quantity give the quantities for the current month, which must be shown in *red* figures. Show each cut, fill, structure, excavation for bridge, culvert, etc., on a separate line; in the case of a structure, it

should be designated under the column of remarks. The road bed quantities must be entered first, with the structure quantity last, in order that the excavation quantities performed by contractors for structural excavations may be readily footed up. Cross balance the graduation quantities, *i. e.*, sum of pay quantities minus waste quantities equals the total embankment. Note in the column of remarks anything effecting the obtaining of this result, such, for example, as material hauled from an adjoining mile. The final estimate will be made up in the same manner, in addition returning summary sheets for each sub-contractor.

Estimates should be made with writing (not copying) fluid. The last sheet should contain a summary of each mile and a total for the residency, deducting the totals of the preceding month, showing thereby the quantities for the month estimated.

One copy of each estimate should be retained by the Resident Engineer, after mailing duplicates to the Principal Assistant Engineer, or to such other office as may be directed.

Progress Profiles.

17. A profile to be used as a monthly progress profile will be prepared on plate A paper, in every respect the same as prescribed for the final profile, in section 64, which will be forwarded as stated in section 15. It will be returned to the Resident Engineer each month, in time for him to post up for the month following.

Show in the color given below the excavation moved and the embankment placed, showing the index of these colors under the title of the profile.

For January .....Cobalt Blue.
" February.....Vermillion.
" March.....Chrome Yellow.
" April.....Venetian Red.
" May .....White.
" June .....Olive Green.
" July.....Vandyke Brown.
" August .....Antwerp Blue.
" September.....Chrome Orange.
" October.....Payne's Gray.
" November.....Scarlet Lake.
" December.....Burnt Sienna.

Resident Engineers will be careful to color all surfaces uniformly. This result can be obtained by mixing sufficient color at one time to fully cover the surfaces to be colored. It is best to use color of no greater consistency than necessary to fully bring out the tint, avoiding the use of thick coloring.

Show the direction excavation is being hauled by arrows and by plotted haul. Note above each structure in ink the date work was begun, the progress for each month by percentage, when completed giving the date and sub-contractor's name. Note the bridge that pile drivers are working on, and such other data as will from inspection plainly indicate the progress made on the residency of each class of work.

Extra Bills.

18. The contract between the Company and the contractors requires "that all claims for extra work or material must be presented to the Chief Engineer

for allowance at the close of each month in which it was done, otherwise the Company is not required to allow or pay for the same."

Resident Engineers will, upon its appearing that extra work is necessary, write the Principal Assistant Engineer for the Chief Engineer's approval for the contemplated work, noting the estimated cost, this approval will be promptly returned to the Resident Engineer and he will attach this approval to the contractor's bill and return both with the monthly estimates, adhering strictly to the contract that no bills will be allowed which are rendered later than the month in which the work was done.

Personal Expenses.

19. Resident Engineers and all members of their parties will pay all their personal expenses and no expense incurred account of the Company will be allowed that has not previously received the approval of the Division Engineer or his superiors; when so approved, the account will be rendered on form No..... to the Principal Assistant Engineer and by him approved and forwarded to the Chief Engineer. Receipts must be attached for all railroad and sleeping car fares, and receipted bills for any material or supplies.

Resident Engineers and parties will board themselves whenever board can be obtained on their residencies. When boarding accommodations cannot be obtained along the line, the party, upon approval of the Principal Assistant Engineer, will be provided with a cook at a salary not exceeding $35.00 per month, camp tents, stoves and tables, and with such camp

equipment as can be supplied by the Company from its stock of equipment, such as cooking utensils, dishes, etc., which it may have on hand; with these exceptions the parties will supply themselves at their own expense.

Responsible for Care of Instruments.

20. The Resident Engineers will be held responsible for the care of the Company's instruments and tools in their charge. On the inside of each instrument case, a copy of the following order will be attached, which explains itself:

OFFICE OF CHIEF ENGINEER.

Upon issue from this office, this instrument box contained the following articles:

.....Transit No.....	.....Screw driver.
.....Plumb box.	.....Camel's hair-brush.
.....Adjusting pin.	.....Oil can.
.....Vernier glass.	.....Storm cover.
.....Sun shade.	.....

This box and its contents are charged against the Engineer to whom it is furnished, directly or by transfer. The cost of any piece destroyed or lost will be charged against the Engineer to whom this box and its contents are entrusted.

Instruments should be carefully packed with excelsior or paper when shipped by express.

The Resident Engineer will see that all Company instruments are carefully used and taken care of, instructing the members of his party to such effect. The rodman should carry his rod when traveling in a wagon.

The cost of any repairs made necessary by the careless or improper care or use of any instruments or tools, will be charged to the Resident Engineer.

Alignment and Check Levels.

21. The Resident Engineer, upon taking charge of a residency, will, as quickly as possible, check all curves and tangents, running check levels over the residency, reporting at once any discrepancies found, referencing all P. Cs., P. Ts. and necessary tangent points, by lines intersecting at right angles at the reference point.

Final Location Stations.

22. The final location stationing is to be maintained throughout, and all records and work are to conform to it. In case of errors found in one station, maintain the stationing by recording the station long or short, as the case may be, giving its correct length. In the case of cumulated error, due to incorrectness of location chaining, pro rate the error so as to bring the stations in agreement with that of the location; the track chaining must also agree with the location stationing.

Mile Posts.

23. The station for each mile will be given the Resident Engineer, and the beginning and ending of miles thus shown are to be maintained throughout in handling the work, and in all the records.

In the case of material hauled from one mile to another, the records, estimates, etc., are to be handled in accordance with section 24.

Hauling Material From One Mile to Another.

24. According to section No. 23, the positions of the mile posts are fixed, and the contractor must arrange with his sub-contractors accordingly. When material is hauled past a mile post, that fact and the quantity moved must be stated in the column of remarks on the estimate sheets and estimate books, on both miles effected. For example: "On mile 51, five hundred cubic yards hauled to mile 50." "On mile 50, five hundred cubic yards hauled into embankment from mile 51." All excavated material (from cuts or borrow pits) must be estimated and placed in pay column on the mile upon which such material was excavated.

Changes in Grades and Alignment.

25. Resident Engineers will not be allowed to make any changes in grades or alignment, but must promptly call their superior's attention to any possible changes that they consider would be beneficial or economical.

Rates of Grade.

26. When any changes in grade lines, or rates of grade, are to be made, care should be used that the rates are in even tenths of a foot, placing the intersection of the connecting grades at a plus if necessary to accomplish such result. Rates of grade of even tenths will be insisted upon, excepting in cases of compensation on curves, when the rate may be carried to hundredths.

Easement Curves.

27. Easement curves will only be used where instructed. When such easements are used, they will have the following off-sets and chords;

4°	Curve	offset	1.09′—50′	chords.
5°	"	"	2.18′—50′	"
6°	"	"	2.44′—40′	"
7°	"	"	3.90′—40′	"
8°	"	"	3.29′—30′	"
9°	"	"	4.70′—30′	"
10°	"	"	4.48′—25′	"

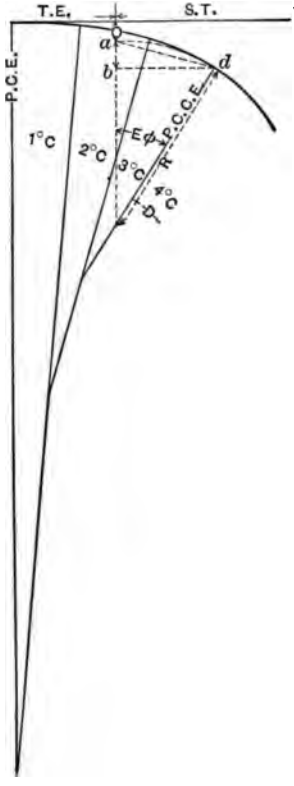


FIG. 1.

The easement curve here described is composed of curves of equal chords, each curve increasing successively from a one-degree curve off the main line tangent to one less in index to that of the main curve D., figure 1, thus: For a five-degree curve the easement will be composed of a 1°, 2°, 3° and 4° curve, in which the offset O., figure 1, is fixed and given above; the other required functions are given on plate II.

FIGURE 1.

P. C. E. Beginning of easement curve.

P. C. C. E. Point of compound with main curve D.

For the easement at P. T. of main curve substitute T. for C., thus P. T. C. and P. T. E.

T. E. = Tangent distance from P. C. E. or P. T. E. to point of offset O., per plate II and figure 1.

E. A. = Total angle of easement curve.

N. = Number of curves in easement.

L. = Length of easement curve = Sum of Chords N.

R. = Radius main curve D.

I. = Total intersection angle.

(R. + O.) Tan. ½ I. + T. E. = Tangent P. C. E. to P. I. = P. T. E. to P. I.

In the required data for recording and running in easements, that for the offsets and chords to be used is given on plate II, and the deflection angles for any position of the instrument is given in plates III, IV, V and VI, in which the position of the transit is indicated by the encircled numbers. When running from P. C. E., the deflections are given in the column containing the position of the instrument as at encircled 3 or the end of 3d chord of 3° curve, the foresight deflections ap-

pearing below, with the backsight above when running towards the main curve D. When running from the end of the main curve toward the tangent, the foresights are above and the backsights below, thus when running an easement curve to a 5° curve, which has an easement curve of four members, plate II offset 2.18′—easement angle 5°—length 200 feet, chords 50 feet and tangent T. E. = 99.9 feet. Add the 99.9 feet to the semi-tangent of the whole curve D. (R + O) Tan. ½ I, gives the distance from P. I. to T. E. With the instrument at P. C. E. the foresight deflections read down as stated above—15′ for first chord, 38′ for second chord on to 1° 53′ for the fourth and last chord or (P. C. C. E.) point of compound curve with the main curve. Set up the transit at this P. C. C. E. and backsight on P. C. E. or station O. of easement and for foresight, deflect 3°.07′, to bring the telescope tangent to the main curve at P. C. C. E. proceeding, run in the 5° curve for the total intersection angle, less 10°, the sum of the two spirals.

Upon arrival at the beginning of the easement curve, at the end of main curve, P. T. C. E., consider the instrument at the end of chord 4, at encircled 4 in the table. As noted above, the foresights in that column, are above, reading up, and the backsights below, reading down. Bring the transit to tangent with the main curve and deflect for each 50 feet successively 1°00′, 1°50′, 2°35′ and 3°.07′ to P. T. E. On main line tangent with instrument at P. T. E. the deflection from a backsight on P. T. C. E. would be 1°53′ the complement of the easement angle as shown opposite 4 on the first column.

It will be readily seen that the instrument can be set up at the end of any chord and the easement curve proceeded with, the backsight and foresight appearing in the respective column containing the encircled number corresponding to the number of chords the instrument is located from the P. C. E. or P. T. E.

Before running the easement curve, the whole of curve D. should be first run in, from the point of offset at its P. C. to its P. T., setting the P. C. C. E. and P. C. T. E. Frequently, in cross sectioning, the actual running of the easement curve need not be done until the track centers are set; the easement curve practically bisects the offset and a stake can be placed there by measurement and the cross section taken.

Connect all compound curves with easement curves when their difference exceeds two degrees, using the table as before, thus figure 2.

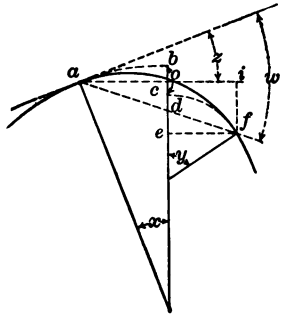


FIG. 2.

The difference between the index of the two given curves Y. X. minus 1, gives the number of chords in

easement curve opposite which in table on plate II, is the required offset O.

Example:

Required, the offset for a spiral connecting a 2° and a 5° curve. 5—(2+1) = 2 N.—then by table we have for 50 feet chords an offset of 0.44 feet. Spiral angle 1°.30′ length 100 feet, and thence from the tables as before described the necessary deflections can be obtained.

Super-Elevation of Curves.

28. On all curves the roadbed is to be finished to conform to a super-elevation equal to 1% of the width of the roadbed for each degree in the index of the curve. The outer edge of the embankment will be raised above the grade at the center line one-half the amount thus obtained, and the inner edge lowered one-half, the center line remaining in conformity with the profile grade; thus, on a 16-feet roadbed on a 4° curve, we have 4% of 16 feet, equal 0.64 feet or 0.3 feet above the grade of the center for outer edge and 0.3 feet below for inner edge.

Except in cases of curves having bridges within their lengths, in which case the grade will be maintained under the inside rail or 2½ feet from the center line, the distances out in both cases will be set at a point where the plane of the roadbed will intersect the side plane of its slope; thus, in the example above, the outside stake should be set out but 7.5 feet and the inside stake 8.5 feet.

Super-elevation will not be graded on any roadbed greater than the rule gives for an 8° curve, and hence

PLATE II.

	25 FT. CORD.				30 FT. CORD.				40 FT. CORD.				50 FT. CORD.			
h.	Number of monitors.	Offset O	Easement Angle E. L.	Length.	T.E.	Number of monitors.	Offset O	Easement Angle E. L.	Length.	T.E.	Number of monitors.	Offset O	Easement Angle E. L.	Length.	T.E.	Number of monitors.	Offset O	Easement Angle E. L.	Length.	T.E.
1	1	.03	0°15′	25	12.5	1	.04	0°18′	30	15.0	1	.07	0°24′	40	20.00	1	.11	0°30′	50	25.00
.66	2	.11	0°45′	50	25.0	2	.16	0°54′	60	30.0	2	.28	1°12′	80	39.99	2	.44	1°30′	100	49.99
.554	3	.27	1°30′	75	37.49	3	.40	1°48′	90	44.99	3	.70	2°24′	120	59.98	3	1.09	3°00′	150	74.97
.500	4	.55	2°30′	100	49.98	4	.79	3°00′	120	59.97	4	1.40	4°00′	160	79.95	4	2.18	5°00′	200	99.93
.466	5	.95	3°45′	125	62.46	5	1.37	4°30′	150	74.94	5	2.44	6°00′	200	99.90	5	3.81	7°30′	250	124.83
.449	6	1.53	5°15′	150	74.92	6	2.20	6°18′	180	89.89	6	3.90	8°24′	240	119.83	6	6.09	10°30′	300	149.66
.427	7	2.28	7°00′	175	87.37	7	3.29	8°24′	210	104.81	7	5.84	11°12′	280	139.64	7	9.12	14°00′	350	174.38
.412	8	3.26	9°00′	200	99.79	8	4.70	10°48′	240	119.69	8	8.34	14°24′	320	159.34	8	13.01	18°00′	400	198.92
.405	9	4.48	11°15′	225	112.17	9	6.45	13°30′	270	134.50	9	11.44	18°00′	360	179.00	9	17.83	22°30′	450	223.22

DEFLECTIONS. 25FT. CORDS. PLATE III.

Number of minutes											Number of minutes
0	0	7'	26'	55'	1°-34'	2°-22'	3°-20'	4°-30'	5°-49'	7°-17'	0
1	8'	1	15'	41'	1°-18'	2°-04'	3°-00'	4°-05'	5°-23'	6°-49'	1
2	19'	15'	2	22'	56'	1°-40'	2°-34'	3°-37'	4°-50'	6°-15'	2
3	35'	34'	23'	3	30'	1°-11'	2°-03'	3°-04'	4°-15'	5°-35'	3
4	57'	58'	49'	30'	4	37'	1°-26'	2°-25'	3°-34'	4°-52'	4
5	1°-23'	1°-26'	1°-20'	1°04'	38'	5	45'	1°-41'	2°-48'	4°-04'	5
6	1°-55'	2°-00'	1°-56'	1°43'	1°-19'	45'	6	52'	1°-56'	3°-10'	6
7	2°-30'	2°-40'	2°-38'	2°-26'	2°-05'	1°-34'	53'	7	1°-00'	2°-11'	7
8	3°-11'	3°-28'	3°-25'	3°-15'	2°-56'	2°-28'	1°-49'	1°-00'	8	1°-07'	8
9	3°-58'	4°-11'	4°-15'	4°-10'	3°-53'	3°-26'	2°-30'	2°-04'	1°-08'	9	9

DEFLECTIONS. 30 FT. CORDS. PLATE IV.

Number of [illegible]											Number of [illegible]
0	0	09'	31'	1°06'	1°52'	2°51'	4°01'	5°24'	6°59'	8°45'	0
1	09'	1	18'	50'	1°33'	2°28'	3°36'	4°55'	6°27'	8°11'	1
2	23'	18'	2	27'	1°08'	2°00'	3°04'	4°21'	5°49'	7°30'	2
3	42'	41'	27'	3	36'	1°26'	2°27'	3°40'	5°06'	6°43'	3
4	1°08'	1°09'	59'	36'	4	45'	1°44'	2°54'	4°16'	5°51'	4
5	1°39'	1°44'	1°36'	1°17'	45'	5	54'	2°02'	3°21'	4°52'	5
6	2°17'	2°24'	2°20'	2°03'	1°35'	54'	6	1°03'	2°20'	3°48'	6
7	3°00'	3°11'	3°09'	2°56'	2°30'	1°53'	1°03'	7	1°12'	2°38'	7
8	3°49'	4°03'	4°05'	3°54'	3°32'	2°57'	2°11'	1°12'	8	1°21'	8
9	4°45'	5°01'	5°06'	4°59'	4°39'	4°08'	3°24'	2°29'	1°21'	9	9

DEFLECTIONS. 40FT. CORDS. PLATE. V.

[illegible]											[illegible]
0	0	12'	42'	1°28'	2°30'	3°48'	5°21'	7°12'	9°18'	11°40'	0
1	12'	1	24'	1°06'	2°04'	3°18'	4°48'	6°33'	8°36'	10°54'	1
2	30'	24'	2	36'	1°30'	2°40'	4°06'	5°48'	7°45'	10°00'	2
3	56'	54'	36'	3	48'	1°54'	3°16'	4°54'	6°48'	8°57'	3
4	1°30'	1°32'	1°18'	48'	4	1°00'	2°18'	3°52'	5°42'	7°48'	4
5	2°12'	2°18'	2°08'	1°42'	1°00'	5	1°12'	2°42'	4°28'	6°30'	5
6	3°03'	3°12'	3°06'	2°44'	2°06'	1°12'	6	1°24'	3°06'	5°04'	6
7	4°00'	4°15'	4°12'	3°54'	3°20'	2°30'	1°24'	7	1°36'	3°30'	7
8	5°06'	5°24'	5°27'	5°12'	4°42'	3°56'	2°54'	1°36'	8	1°48'	8
9	6°20'	6°42'	6°48'	6°39'	6°12'	5°30'	4°32'	3°18'	1°48'	9	9

DEFLECTIONS. 50FT. CORDS. PLATE. VI.

Hundreds of Minutes											Hundreds of Minutes
0	0	15'	52'	1°-50'	3°-07'	4°-45'	6°-41'	9°-00'	11°-38'	14°-35'	0
1	15'	1	30'	1°-22'	2°-35'	4°-07'	6°-00'	8°-11'	10°-45'	13°-38'	1
2	38'	30'	2	45'	1°-52'	3°-20'	5°-08'	7°-15'	9°-43'	12°-30'	2
3	1°-10'	1°-08'	45'	3	1°-00'	2°-22'	4°-05'	6°-08'	8°-30'	11°-13'	3
4	1°-53'	1°-55'	1°-38'	1°-00'	4	1°-15'	2°-52'	4°-50'	7°-08'	9°-45'	4
5	2°-45'	2°-53'	2°-40'	2°-08'	1°-15'	5	1°-30'	3°-22'	5°-35'	8°-08'	5
6	3°-49'	4°-00'	3°-52'	3°-25'	2°-38'	1°-30'	6	1°-45'	3°-52'	6°-20'	6
7	5°-00'	5°-19'	5°-15'	4°-53'	4°-10'	3°-08'	1°-45'	7	2°-00'	4°-22'	7
8	6°-22'	6°-45'	6°-47'	6°-30'	5°-52'	4°-55'	3°-38'	2°-00'	8	2°-15'	8
9	7°-55'	8°-22'	8°-30'	8°-17'	1°-45'	6°-52'	5°-40'	4°-08'	2°-15'	9	9

for a 10° curve it will be the same as for an 8° curve. This super-elevation will usually be carried back on the tangents to a distance from the P. Cs. and P. Ts. equal to 50 feet per degree of the index of the curve up to 4°; for all curves over 4° reduce the length (50) by 5 feet for each additional degree of the index, giving 20 feet for each degree at the end of a 10° curve.

Where easement curves are used, the run-off will be made in the length of the easement curves.

Vertical Curves.

29. At all changes of grade where the algebraic difference exceeds 0.2 feet stake out a grade line on a vertical curve, using uniformly a length of 400 feet at all summits, unless otherwise instructed, and of such lengths as directed, in all sags, where it is desirable to obtain much longer curves whenever possible. If it can be avoided, the maximum rate of change per station in sags is not to exceed .05 feet.

All vertical curves will conform to the following formula and example, per figure 3.

The algebraic difference between the rates of the grade, multiplied by half the length of the vertical curve equals A.

The ordinates O. are each a fractional part of A., the length of the vertical curve in stations squared, is the common denominator of the fraction representing the frational part that any ordinate is of A., and the number of stations from the P. C. of the vertical curve at which an ordinate height is required squared, is the numerator of that fraction.

When an ordinate is required at a plus, as the plus

of a pile bridge bent, consider the plus as a decimal of a station.

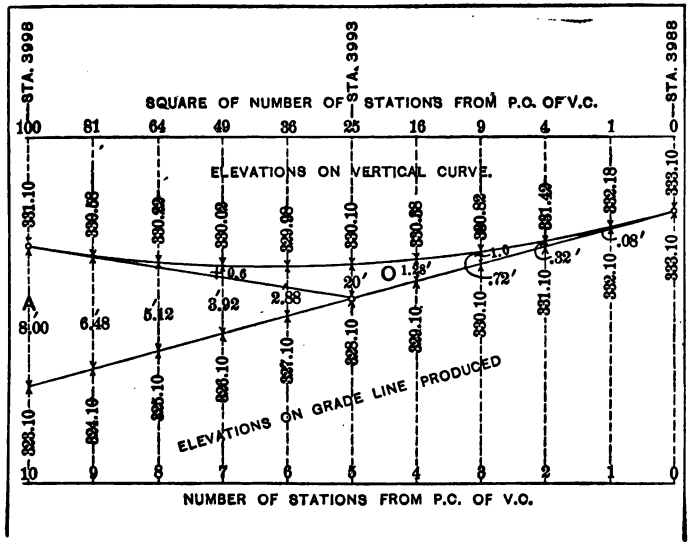


FIG. 3.

Example:
Length of curve 10 stations = L.
Rates of grade + 0.6 and − 1.0.
Algebraic difference 1.6. $(1.6 \times \frac{1.0}{2}) = 8.0 = A.$
$L^2 = 10^2$ = common denominator = 100.
Ordinate at station 4 from the P. C.

$$= \frac{4^2}{10^2} = \frac{16}{100} \times 8 = 1.28.$$

Elevation at station 4 on the 1% grade = 329.10, this plus 1.28 = 330.38, the elevation on vertical curve.

Staking Out the Work.

30. As soon as possible, the cross sectioning should be completed, platting each cross section and calculating its area the night of the day it is cross sectioned, as prescribed in section 10.

All work, however minute, should be staked out, ditches, changes of channel, width of right of way, etc., and width of all berms. Staking out all excavations and embankments to sub-grade, corresponding to the grade line shown on the profile and in accordance with the roadbed prescribed in the specifications, unless otherwise specifically instructed. Bridge ends will be staked out to conform with the instructions noted on the standard plan for masonry and pile and trestle bridges, see section 34.

Substantial stakes must be used and be well driven, blazing front and back of side stakes, marking the proper station on the side from the roadbed and the cut or fill on the other; marking also the cut or fill on the back of center stake.

When cross sectioning curves, sufficient cross sections must be staked to insure a distance of not more than 50 feet between any two staked cross sections.

Surface Ditches.

31. Surface ditches should be staked out and be excavated at the same time cuts are opened; ditches must be neat and regular, placing all material excavated on the lower side in a continuous uniform bank, forming a levee, adding to the value of the ditch, when thus wasted in the levees, and to be estimated as excavation wasted.

No surface ditch must be less than one and one-half feet deep, and two feet wide on the bottom, nor nearer than 10 feet to the edge of any cut. (See figure 4.) In staking out these ditches, great care must be used to obtain a proper grade in order to prevent injurious cutting and washing. Ditches must be led away at the ends of cuts in order to prevent water running against embankments.

Cut Ditches.

32. Cut ditches must not be less than shown in figures 4 and 5. Contractors must leave ditches clean so they will drain, making the ditches larger at their outlets so that water will not run against embankments and cut injurious gullies.

Berm Ditches.

33. Where embankments are made from excavation, and there is no borrow pit to act as a ditch to keep the surface water away from the embankment, berm ditches will be excavated (see figure 6), and made as large as the case may require.

All berm ditches will be staked out, and have the material excavated from them, placed in the embankment before any material from the cut is put into the embankment.

End of Embankments.

34. Ends of embankments at bridge openings will be staked, per sample of the final estimate field book, page 1–A; *i. e.*, a wedge and two quarter cones, estimating the contents by the formula on page 33, in which H. is the average height and R. the average radius.

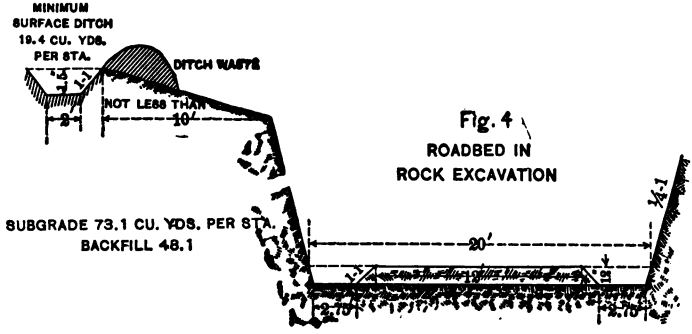


Fig. 4
ROADBED IN
ROCK EXCAVATION

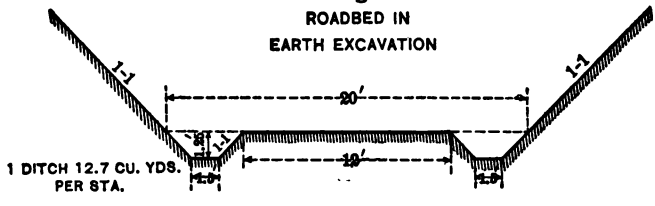


Fig. 5
ROADBED IN
EARTH EXCAVATION

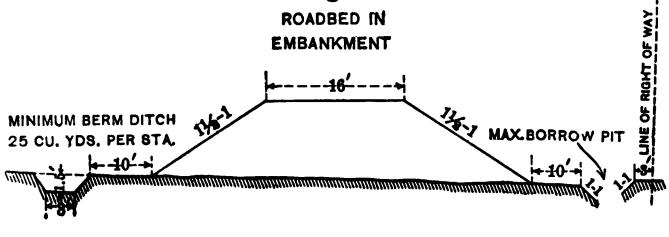


Fig. 6
ROADBED IN
EMBANKMENT

$R^2 \times H \times .0097$ cubic yards in quarter cone.
Sum of the two end areas $\times \frac{1}{2}$ roadbed $\times .037$
= cubic yards in wedge.

All embankments at bridge ends are to be staked out with the roadbed 2 feet wider than called for in the specifications, tapering back to the specification width in 27 feet.

Quantities to Be Made Up.

35. Final estimate quantities are to be made up as rapidly as possible, and the final estimate completed as fast as the work is finished beyond doubt of change, to the end that such final estimate and all construction records will be completed and ready to turn in immediately after the completion of construction.

Graduation quantities will be arrived at by the method of average end areas. Resident Engineers must take cross sections with sufficient frequency to avoid a greater difference than 3 feet between the center heights of adjoining cross sections, and when passing from cut to fill obtaining a cross section for each grade point, as such grade points occur on the left, center or right. In estimating quantities at the ends of cuts where the prism has only one end area running to a grade point at the other, estimate as a pyramid instead of as a wedge; *i. e.*, the end area by one-third of the length.

Estimates to Contractors.

36. Resident Engineers will not give contractors any estimates or statements, signed or unsigned, of work performed, without such estimates or statements bear the signature of the Division Engineer or other superior.

Clearing.

37. Clearing must not be piled off the right of way, unless the contractor first secures the consent of the owner in writing, which consent is to be forwarded by the Resident Engineer to the Principal Assistant Engineer. Clearing must not be piled within the reach of high water, from where it can be floated back on the right of way, into the openings. Resident Engineers will bear in mind that in all overflow districts there is a current both ways, the incoming and outgoing backwater. The specification clause as to burning all brush and timber must be fully enforced, to the end that all clearing must be entirely removed from the right of way. Dead and leaning trees outside the right of way, which if blown down toward the telegraph line or track would obstruct or damage either, are to be carefully selected and cut down.

Grubbing.

38. Cavities left by reason of powder being used to blow out stumps must be carefully and tightly refilled; the use of powder for this purpose is to be discouraged, grubbing being more preferable. If the Resident Engineer neglects this inspection, bad settlements will eventually take place in embankments; this applies only to grubbing under embankments.

The Resident Engineers will record, by a rough sketch and measured distances, at the time they cross section, all stumps under embankments that are required to be grubbed out, in order that any left in and filled over can be readily detected and ordered removed.

See that all grubs are removed from the right of way or burned up the same as clearing.

Roadbed Excavations.

39. Resident Engineers will give centers through the excavations as the work progresses to insure the contractors excavating true to the required slope, insisting on all slopes being cleaned down as the work progresses, and when the material will permit of its being done by pick or shovel, it should be done in such manner. The slopes must be cut true to the surface of prisms.

Back Filling in Cuts.

40. No back filling in rock cuts must be done until they are excavated 1 foot below grade. The material used for back filling must be good surfacing material, preferably clean broken stone; no clay, slate, or shale will be allowed. Back filling is to be estimated as embankment borrowed.

Limit of Haul.

41. It must be thoroughly understood that all excavated material is to be hauled to the limit, where the cost of overhaul per yard equals the price per cubic yard of earth excavation; any excess of excavation after this may be wasted below grade by widening the embankments uniformly within the free haul limit, on both sides.

No waste is to be placed on the sides of cuts nor overhaul paid on waste without the consent of the Division Engineer.

The contractor should be instructed as to the amount, direction, and disposition of all excavation material to be hauled, which is to be determined by the plotted haul, to the end that the haul each way will give the least pay haul.

Embankments.

42. The clause in the specifications which requires embankments to be built full to the slopes from their base up must be enforced by the Resident Engineer, particularly when built of clay or gumbo material, insisting on the contractors bringing up embankments in benches of not more than 4 feet in height and all fills topped at least 1 foot deep with surface material of the best quality obtainable.

Before acceptance, the width between slope stakes should be checked up, and noting that the prisms are full. (See section 47.)

Borrow Pits.

43. No borrow pits will be excavated below the grade of openings through which they are to drain, nor across the outlet of any openings, and the contractors should be shown how to excavate the pits, so that when finished they will drain their entire length.

Borrow pits must be left in a neat and clean condition, excavated so as to leave the specification width of berm with side slopes of not less than 1 to 1, and be excavated no nearer to the right of way lines than 3 feet, measured on the natural surface as shown by figure 3, page 29.

The quantities to be borrowed are to be arrived at from the plotted haul and the contractors are to be in-

structed where, and how much to borrow, to the end that the necessary borrow may not be exceeded, leaving excavation to be wasted.

Shrinkage.

44. Resident Engineers will consult with their Division Engineers as to the amount of shrinkage that will be required on the various embankments, which is governed by the various kinds of material, proximity of bridges, and nearness of the track laying.

This shrinkage will be placed on embankments before setting the final finishing stakes, and it is to be placed uniformly on top and slopes, the amount determined on will be a per cent of the height. The contractor must be informed of the amount of shrinkage that he will be required to put on before he completes roughing in the embankment.

Swell.

45. The swell of solid rock excavated from cuts hauled into embankments will be taken into account, to an amount equal to the actual swell that occurs, except in the case of solid rock excavation obtained from borrow pits, the swell in that case being provided for by the specifications by which one cubic yard of solid rock excavated from a borrow pit is to be estimated as making one and one-half cubic yards of embankment. Such a borrow pit, however, is not authorized until approved by the Chief Engineer. The swell actually taking place in material hauled from roadbed excavations into embankments must be determined by the Resident En-

gineers by arriving at the actual cubic yards of embankments made by the solid rock material hauled.

Station Grounds.

46. Resident Engineers will ascertain the location of all station grounds and sidings as early as possible. No borrow pits are to be made within the limits of the station grounds. Resident Engineers will consult their superiors and obtain full instructions before permitting the contractors to commence work on the station grounds.

Finishing Stakes.

47. Long, substantial finishing stakes are to be set to grade on each edge of the roadbed, measuring out half the width of the roadbed from a run in center line; placing them every 100 feet on tangent and every 50 feet on curves. The contractors must be required to make a full shoulder, made to a line stretched from stake to stake.

The prisms of embankments must be full, and shoulders should not project beyond the slope of the embankment. The top of all grade stakes will be "keiled," and before acceptance the grade over embankments and through cuts, will be checked, seeing that ditches are of proper depth and fully excavated, and that the roadbed between grade stakes is without sag and true to the grade line.

Drags or any method of finishing that will disturb the grade stakes must not be permitted, and before acceptance displaced grade stakes must be replaced. Neat, true to the prism grading work will be required.

Track Centers.

48. Use 2-inch square stakes for track centers, 2 feet long in all earth roadbeds and 20 inches long in back-filled roadbeds, driving them to leave 7 inches projecting above sub-grades; use a bar and sledge when necessary to drive them. Put centers in at every station on tangents, every 50 feet on curve, and at each P. C. or P. T., and at the end of each chord of easement curves. Mark the station in full on the front of each station stake.

Permanent Monuments.

49. As soon as the track is laid, all P. Cs. and P. Ts. must be permanently monumented together with the beginning and ending of each easement curve. Standard monuments for this purpose can be obtained by requisition.

Permanent Bench Marks.

50. Place permanent bench marks at least every half mile, and when possible establish them on masonry bridge seats, stone culvert steps, or other substantial and permanent objects. When such structures are not on the work with sufficient frequency requisition should be made for standard bench marks.

Record on the last pages of the final estimate book of graduation the elevation, description and location of each permanent bench mark establishd on the miles estimated in the book.

Pile and Trestle Bridging.

51. Stake out all pile bridges in accordance with the standard plan, setting a stake for each pile; the stakes

for the outside pile of each bent to be such a distance out as is required to secure the batter called for on the plan.

Blue prints of ravine sections showing the design of each opening, together with the bill of material for each, will be supplied to the Resident Engineers, who will promptly upon receipt, check up all bills and at once notify the Principal Assistant Engineer's office of any discrepancies or errors.

Changes in Frame and Pile Bridges.

52. No changes will be made by the Resident Engineer in the length of pile and frame bridges from that shown on the ravine sections, but he will call the Division Engineer's attention to any such change as he may deem advisable, and upon approval of any change will forward to the Principal Assistant Engineer a revised bill of material for the whole structure, accompanied by the Division Engineer's approval in writing.

With the approval of the Division Engineer, minor changes may be made in the location of pile or frame bridges from that shown by the ravine section.

Change in Class of Structure.

53. Resident Engineers will look into the sufficiency of all drainage openings of every description, and if it should appear that the structure designed and billed should be changed, they will, with the approval of the Division Engineer, make necessary changes. A request for approval must be accompanied by a new bill of material with a report covering fully the reasons for proposing the change.

Details of Pile and Frame Bridges.

54. Care should be used that all details are constructed according to the standard plan; full batter to outside piles, piles water tabled, bents jacked and braced to true position, cut-offs level, all timbers sized to a true and full bearing, ends sawed square and to even lengths, ends of ties and caps cut to a line from end to end of the bridge, dump boards trimmed true to slope, ties sized to full bearing without shoulders, over entire chord, and every bolt in place and full washered.

Timber is to be estimated in place (the price for which includes iron) in accordance with the bill as to length, every stick billed should be used, and if not used, turned over to the Company, or deducted from the estimate.

Timber Inspectors.

55. A Chief Timber Inspector will be appointed by the Chief Engineer, and is instructed to place his inspection mark on the *edges* of all sticks used in structures. Resident Engineers will inspect all timbers delivered at openings, and also after it is in place in the structure to see that no timber bearing other than the inspector's acceptance is used.

Pile Recorders.

56. Pile recorders will be appointed by the Principal Assistant Engineer or the Division Engineer, and they will report to the Resident Engineer of the residency upon which they are recording.

Upon arrival on a residency, they will immediately report to the Resident Engineer, who will provide them

with a ruled and headed pile record book, per sample section 12, and with ravine sections showing the pile openings on the residency together with bills of piling ordered for each opening which the recorder will enter in the pile record book.

Resident Engineers will be held responsible for the proper keeping of the pile record by the recorder, whom the Engineer will especially instruct in regard thereto, in accordance with section 12. Pile recorders, when leaving a residency, will leave the pile record book with the Resident Engineer.

Staking Out Masonry Work.

57. All culverts and masonry structures must be staked out on the plan furnished the Contractor's Foreman, and location of all stakes must be shown. The stakes for the inside and end building lines should be set far enough back from the work to permit of its being carried on without disturbing the stakes, and so that a line stretched from tack to tack will intersect at the neat corners.

All center lines for culverts must be laid out with a transit, and whenever possible at right angles with the center line, noting in all cases that end walls are parallel with the center line or at right angles to the radius of the curve.

Especial care must be taken to insure the proper position of end walls, wing walls, etc., in the slopes of embankments.

Foundation Pit.

58. Excavation pits for masonry, when of stone, will be staked out 6 inches greater than the greatest dimen-

sions of structure, and to the dimensions of footing course in concrete structures founded without grillage.

All material excavated from foundation pits, when within haul of embankment, is to be placed therein and estimated as excavation hauled and borrow quantities reduced accordingly. This does not apply, however, to material required for banking cribs or which would be unfit for embankments, but it must be understood by contractors that material excavated from abutments or pier pits must not be placed in channels or where it will in any way reduce the waterway.

Inspection of Foundations.

59. Resident Engineers will allow no important structures, such as abutments, piers and large culverts, to be started until their immediate superior has examined and approved the depth of pit and material reached to found upon. In the case of minor structures, box drains, etc., the Resident Engineer's approval will be considered sufficient unless otherwise instructed.

Masonry Inspection.

60. A Chief Masonry Inspector will be appointed to report directly to the Resident Engineer's superior. The Chief Masonry Inspector will appoint all Masonry Inspectors, subject to the approval of the Division Engineer or the Principal Assistant Engineer. These Masonry Inspectors will be held responsible for the performance of all masonry work in accordance with the specifications and the plans.

The Resident Engineer will make all plans, and give all dimensions and elevations, which are to be strictly

followed by the contractors and inspectors. The authority of the Resident Engineer extends only to the location and plan of masonry structures, and from the dimensions and elevations thereon he is to determine and return the quantities for all monthly and final estimates.

The Masonry Inspector's duties are to see that the contractor complies in all respects to the quality of material required and the performance of the work.

Copies of Standard Plans.

61. Resident Engineers will call for blue prints of the standard plans of all structures that will be erected on their residency, and in accordance with them make all necessary detailed drawings, showing thereon all dimensions and details in conformity to the standard plans furnished. A copy of these detailed plans for masonry, etc., must be furnished to the Contractor's Foreman. In concrete work the forms should be designed by the Resident Engineer, giving sufficient dimensions to enable the contractor to erect the forms to the required batters and dimensions.

Observation During Storms.

62. During severe storms, Resident Engineers should go over their line, closely observing the quantity and action of the storm water run-off, with a view of determining more definitely the sufficiency of openings and ditches, or the need of larger openings or ditches than those contemplated, and the advisability of reducing those intended, reporting the result of their observations to the Division or Principal Assistant Engineer.

Final Estimates.

63. All final estimates will be made up with writing ink (not copying ink), that for all graduation clearing and grubbing in the standard field cross section book, per sample leaves, pages 46, 47, 48, 49, 50 and 51, fully explaining by marginal notes the disposition and classification of all quantities. These notes must be full and sufficient to enable the making from them of a summary, per sample, pages 52, 53, 54 and 55, which summary will be the original of what is to appear on the final estimate sheets (Form C–4), and must cross-balance as described in section 16.

Clearing and grubbing must be shown on a page by itself, and the stations given between which clearing and grubbing is estimated, together with the sub-contractor's name and the totals, placed in the summary.

The notes for all excavation quantities not entered in the cross-section book are to be referred to by a notation, giving the book and page upon which they appear, such as foundation pits and excavations around bridges, the data for which is shown in the bridge final estimate book (see section 11).

A total summary must be made showing each mile on a separate line for the entire residency at the end of the last book, signing it as correct.

All cross sections must be inked in, in the plat cross-section book, showing fully the classification lines and at the end of each cut the total classification for such cut.

The final estimate in detail for all bridges, sub-structures, boxes, open culverts, pipe drains and other struc-

SECTION.

STA.	ELEVA	GRADE.	CUT OR FILL — LEFT.	C.	RIGHT.
3998	318.90	331.10	-12 / 26.0	-12.2	-13.0 / 27.5
H.B.+50	318.20	331.40	-12.5 / 27.9 -13.0 / 9.0	-13.2	-13.2 / 9.0 -13.4 / 29.4
D° 1050	6 Bent	Pile Br.	-12.8 / 19.2 -13.0 / 19.5		-13.2 / 19.8 -13.2 / 19.8
See page	book	for estimate			
			-12.8 / 19.2 -14.0 / 21.0		-13.8 / 20.7 -13.8 / 20.7
3999+23 N.B.	318.30	331.84	-12.6 / 27.9 -13.1 / 9.0	-13.5	-13.8 / 9.0 -14.0 / 30.0
4000	318.70	332.30	-12.7 / 27.0	-13.6	-14.0 / 29.0
+50	318.90	332.60	-13.7 / 28.5	-13.7	-14.3 / 29.5
4001	317.90	332.90	-15.1 / 30.6	-15.0	-17.6 / 34.4
+35	315.70	333.11	-16.2 / 32.3	-17.4	-17.6 / 34.4
+50	316.40	333.20	-17.3 / 34.0	-16.8	-17.6 / 39.4
+85	316.90	333.41	-17.3 / 34.0	-16.5	-16.0 / 32.0
2	318.20	333.50	-16.2 / 32.3	-15.3	-14.2 / 29.3
+50	323.70	333.80	-11.4 / 24.8	-10.1	-9.8 / 22.7
3	329.10	334.10	-6.0 / 17.0	-5.0	-5.3 / 16.0
+50	331.40	334.40	-2.2 / 11.3	-3.0	-4.4 / 14.6
4	332.30	334.70	-1.4 / 10.1	-2.4	-3.6 / 13.4
+22	Add	for	Wash 24.0' X 7.0' X 1.5'		
+82	334.60	335.19	0.0 / 10.0	-0.6	-1.2 / 9.8

100' V.C.

0.68

16' ROAD BED

AREAS					Cubic Yards.		Remarks.
EXCAVATION			Embankment.		EXCAV.	EMBANK.	
						1755.0	forward
			426.	35		473.7	
			491.	56		849.9	
						183.1	
						3261.7	Est. 3261.7 Cu. Yds. Emb.
			511.	24		199.4	Made from cut East and borrow berm ditch 436.4 cu. Yds.
			487.	60		1424.3	
			509.	30		923.1	Berm Ditch.
			618.	30		1044.1	Est. 50 cy. Exc.
			715.	49		864.5	
			714.	16		397.1	
			677.	70		902.1	
			592.	84		352.9	
			324.	67		840.5	
			127.	70		418.9	
			65.	25		178.7	
			48.	20		105.0	
						9.3	
			10	74		89.5	
						7758.4	

SECTION

STA.	ELEV.	GRADE	CUT OR FILL LEFT	C	RIGHT
+93	335.30	335.26	+ 0.2	0.0	- 0.7
			10.2		9.0
4005	335.50	335.30	+ 0.5	+0.2	0.0 -0.2
			10.5		4.0 8.3
+06	335.70	335.34	+ 0.8	+0.4	0.0
			10.8		10.0
6	341.00	335.90	+ 5.1	+5.1	+ 5.0
			15.1		15.0
+50	343.40	336.20	+ 6.7	+7.2	+ 7.5
			16.7		17.5
7	344.90	336.50	+ 7.9	+8.0	+ 8.6
			17.9		18.6
50	346.40	336.80	+ 9.6	+9.6	+ 9.6
			19.6		19.6
8	346.20	337.10	+ 9.8	+9.1	+ 8.3
			19.8		18.3
+50	343.60	337.40	+ 7.5	+ 6.2	+ 4.7
			17.5		14.7
+75	330.80	337.55	+ 3.0	+ 2.3	+ 1.3
			13.0		11.3
+85	337.60	337.61	0.0	0.0	0.0
			10.0		10.0
9	334.20	337.70	- 2.5	-3.5	- 2.8
			11.7		11.9
+25	332.90	337.85	- 3.8	-4.9	- 5.0
			13.4		15.5
+50	330.70	338.00	- 5.2	-7.3	- 8.2
			16.5		20.3
+75	330.40	338.15	- 7.9	-7.8	- 8.1
			19.1		20.2
4009+75	Timber	Box---	2X2'		
4010	333.20	338.30	- 5.2	-5.1	- 4.6
			15.8		14.9
+41	338.60	338.55	0.0	0.0	0.0
			10.0		10.0

30' ROAD BED

18' 2-8

AREAS					Cubic Yards.		Remarks.
EXCAVATION.			Embankment.		EXCAV.	EMBANK.	
						7758.4	forward.
1.	00		2.	80	0.2	2.8	
3.	95		0.	40	0.6	0.4	
8.	16		0.	0	1.3	0.1	
127.	25				235.7	7761.7	Est. 7761.7 Cu. Yds. Emb. " 1587.1 " " f. Bor.
194.	12				297.6		
235.	80				398.1		
284.	16				481.4		
263.	85				507.4		
160.	82				393.2		
49.	44				97.3		
0.	0		0.	0	9.2	0.0	Est. 1712 C.Y. Backfill
					24220		Est. 24220 C.Y. Exc.
			61.	70		17.1	Est. 260.2 C.Y. Exc. S.G.
							Est. 1900.0 C.Y. E
			105.	20		77.3	Est. 782.2 C.Y. S.R.
			189.	92		136.6	Solid Rock Swelled 50%
							2484.3 C.Y. hauled & free
			215.	27		187.6	1979 " " "
			117.	48		154.0	- Box foundation - Est. 75 C.Y. E. Exc. into Emb.
0	0		0.	0	0.0	89.2	
						661.8 / 15.8	Box displacement Est. 646.0 C.Y. Emb.

SECTION

STA.	ELEVA.	GRADE.	CUT OR FILL		
			LEFT.	C.	RIGHT.
4011	345.70	338.90	+ 6.8 / 16.8	+ 6.8	+ 6.8 / 16.8
+ 25	347.00	339.05	+ 8.5 / 18.5	+ 7.9	+ 7.7 / 17.7
+ 70	347.90	339.32	+ 9.0 / 19.0	+ 8.6	+ 6.5 / 16.5
12	345.90	339.50	+ 7.7 / 17.7	+ 6.4	+ 5.0 / 16.0
+ 25	345.00	339.65	+ 6.5 / 16.5	+ 5.3	+ 4.0 / 14.0
+ 65	341.00	339.89	+ 2.4 / 12.4	+ 1.1	+ 0.0 / 10.0
+ 73	339.90	339.94	0.0 / 10.0	0.0	0.0 / 10.0
+ 80	341.40	339.98	+ 1.5 / 11.5	+ 1.4	+ 1.3 / 11.3
13	345.60	340.10	+ 4.7 / 14.7	+ 5.1	+ 5.5 / 15.5
+ 40	348.20	340.34	+ 7.9 / 17.9	+ 7.9	+ 7.9 / 17.9
14	349.40	340.70	+ 9.4 / 19.4	+ 8.7	+ 8.0 / 18.0
+ 60	349.70	341.00	+ 9.4 / 19.4	+ 8.7	+ 8.4 / 18.4
+ 15	347.70	341.30	+ 7.4 / 17.4	+ 6.4	+ 5.5 / 15.5
+ 69	350.20	341.71	+ 9.4 / 19.4	+ 8.5	+ 7.7 / 17.7

AREAS					Cubic Yards.		Remarks.
EXCAVATION.			Embankment.		EXCAV.	EMBANK.	
182.	24				199.1		
223.	99				188.0		
230.	15				378.4		
168.	14				221.3		S.O. 90 CU. YDS. L. EXC. WASTED INTO LEVEE.
133.	32				139.6		
24.	32				116.8		
0	0		0	0	3.6		
29.	96				3.9		
128.	01				58.5		
220.	41				258.1		
249.	69				522.3		
253.	43				465.8		
169.	78				391.9		
243.	17				527.7		
					3475.0		Est. 3475.0 CU. YDS. L. EXC. " 139.8 " " L. EXC. C. D. 3614.8 " " HAULED.
							365.6 CY. HAULED EAST FREE 3249.2 CY. HAULED EAST 775 Est. 76181 CY O.H 100

SECTION

STA.	ELEVA.	GRADE	CUT OR FILL		
			LEFT C RIGHT		
	——	Summary of Mile 76 ——			
Sta.		Emb.	Exc.	Bor.	Waste
3983+30	3972+00		12543.7		
"	"		201.2		
"	"		135.0		135.0
3972+00	3982+75	12240.9	34.0	23780	
"	"		275.0		
3982+75	3986+50		836.2		
"	"		63.2		
3986+50	3989+30	1882.5	1193		
3989+30	3991+00		1323.6		
"			40.0		
3991+00	3991+60	70.5	4.0		
3991+60	3995+60		2811.8		
"	"		80.0		
3995+60	3998+50	3261.7		436.4	
3999+23	4004+82	7761.7	50.0	1587.1	
4004+82	4008+85		2422.0		
	FORWARDED	25217.3	20939.2	4401.5	135.0

AREAS					Cubic Yards		Remarks
EXCAVATION			Embankment		EXCAVA.	EMBAN.	
Earth			Loose Rock		S.A	Overhaul	
12543	7						3691. CY HAULED TO ML 75
201.	2						CUT DITCHES.
135.	0					22635	90544 cy OH 250 = 22635 cy OH 100 SURFACE DITCHES.
2412.	0						3974+80 4x4 BOX. 3980+40 3x3 BOX.
275.	0						BERM DITCH.
836.	2						
63.	2						CUT DITCHES.
119.	3						SURFACE DITCH.
1323	8						
40.	0						CUT DITCHES.
40							3991+30 - 2X2 BOX.
2811.	8						
80.	0						CUT DITCHES.
436.	0						
1637.	1						BERM DITCH.
1000.	0				522.0		
24 818	7				522.0	22635	FORWARDED.

SECTION.

STA.	ELEVA.	GRADE.	CUT OR FILL		
			LEFT.	C.	RIGHT.
		— Summary of Mile 76 —			
Sta.		Emb.	Exc.	Bor.	Waste.
	FORWARD →	252173	20939.2	4401.5	135.0
4004+82	4008+85		260.2		
,,	,,	171.2		171.2	
,,	,,		60.0		60.0
4008+85	4010+41	646.0			
,,	,,		75.0		
,,	,,		7.5		
4010+41	4015+69		3475.0		
			139.8		
			90.0		90.0
	TOTALS →	26034.5	250467	4572.7	285.0

AREAS					Cubic Yards		Remarks
EXCAVATION			Embankment		EXCAVA.	EMBAN.	
Earth			Loose Rock		S.R	Overhaul	
24818.	7				522.0 2602	22635	→ FORWARD S.O. { S.R SWELLED 50% 3911 CYS
171.	2						
60.	0						S. D.
75.	0						B.D.
7.	5						4009+75 2'x2 Bar.
3475.	0						
139.	8						C.D.
90.	0					25181	32892 cy 0'+75+25181 0+100' S.D.
28837.	2				782.2	47816	← TOTALS

tures pertaining to the care of drainage is to be returned in the bridge book, as instructed in section 11. Such book must show quantities, classification and disposition, and the notes necessary to check the quantities, together with the name of the sub-contractor actually doing the work.

In the final estimate book of graduation note the page and book number where all graduation quantities performed for drainage purposes are estimated. Resident Engineers will ink in every note and line in the summary and date and sign as correct.

Final Profile.

64. A final profile must be made, as per sample plate VII, on a continuous roll of plate A profile paper, in scale 200 feet wide and long enough to leave 18 inches of blank paper at each end. At each end placing a plain, neat title, per figure 7, and on the outside edge at both ends of the profile write:

Final Profile, Residency No. 4.
Miles 22 to 32.
Station 1162 to 1637.

The general style, form and make-up of this profile is to be in accordance with the sample shown on plate VII, which is to be strictly followed, with over-haul platted as shown. Give the station and plus of the Memphis end of stringers on pile and girder bridges, center of end pin of pin bridges, center of all pipes and covered culverts, center of road crossings and cattle guards; names of rivers, creeks, towns and stations; lengths of sidings, alignments, bench marks and clear-

ing. Show the fencing with a line for each fence, with another line show the lineal feet of rock ballast placed (when such work is performed before completion of profile).

Fig. 7.

PROFILE

accompanying

FINAL ESTIMATE—RESIDENCY No 4

CHOCTAW, OKLAHOMA & GULF R.R.

MILES 22 to 32

STA. 1162 to 1637

Work commenced Nov. 5th-'98 W.E.H.

" finished July 10th-'99. Res. Eng'r.

Note! In case of construction under another corporation name, insert its name in place of Choctaw, Oklahoma & Gulf. Use this form of title for Progress profile, leaving out "accompanying," and inserting "Of Progress" in place of the words "Final Estimate."

Plotting and Computing Haul.

65. In plotting haul consider each small horizontal space (one foot when plotting profile) 100 cubic yards, and from some base line as the 50 feet line X. Y. on plate VII, plot the "haul curve," A. B. C. D., etc., in the following-described manner:

The fill station 3999 + to 4004 +.

In the cut east of M. P. 76 there is:

3475.0 C. Y. above the roadbed, and
139.8 " in cut ditches, giving
Total in cut. . . 3614.8 " of which
east of station
4011 + 18 365.6 " was hauled in to fill station 4010, leaving 3249.2 " to haul east to fill station 4000.

In the cut station 4004 + to 4008 + there is

1900 C. Y. earth,
and 522 " solid rock,
and 260.2 " solid rock in sub-grade.
Total in the cut. . . . . 2682.2 " of which all
west of station 4008+38 . . . 197.9 " was hauled in to the fill station 4010, leaving 2484.3 " to go into the fill station 4000.

Inspection shows that the quantities placed in fill station 4010 lie within the free haul (which is 500 feet).

To find the haul on the quantities going into the fill at station 4000, begin at the west end of the material hauled, M. P. 76. In the 69 feet of station 4015 to 4016 there is, including ditches, 543.6 c. y.; with X. Y. as a base line, and each horizontal space equaling 100 c. y., plot "A" 543.6 c. y., below the base line, and from plus 69 on the base line to the point A. draw the "haul curve." Then between stations 14 and 15, including ditches, there is 880.7 c. y., which, added to 543.6 c. y., gives 1424.3 c. y., and at station 4014, 1424.3 c. y., below the base line, plot the point B. and draw the "haul curve" A.—B. In this manner suc-

cessively find the points C. D. and E., and through these points draw the "haul curve," adding in all material that is hauled from each station to the fill, deducting in like manner any that may be wasted. Thus we find that at the mouth of the cut the "haul curve" passes through the point E., or 3249.2 c. y. below the base line at station 4011 + 18.

A point on the curve one-half of this 3249.2 c. y., or 1625 c. y. below the base line, is the center of bulk of that portion of this cut hauled to the fill, station 4000.

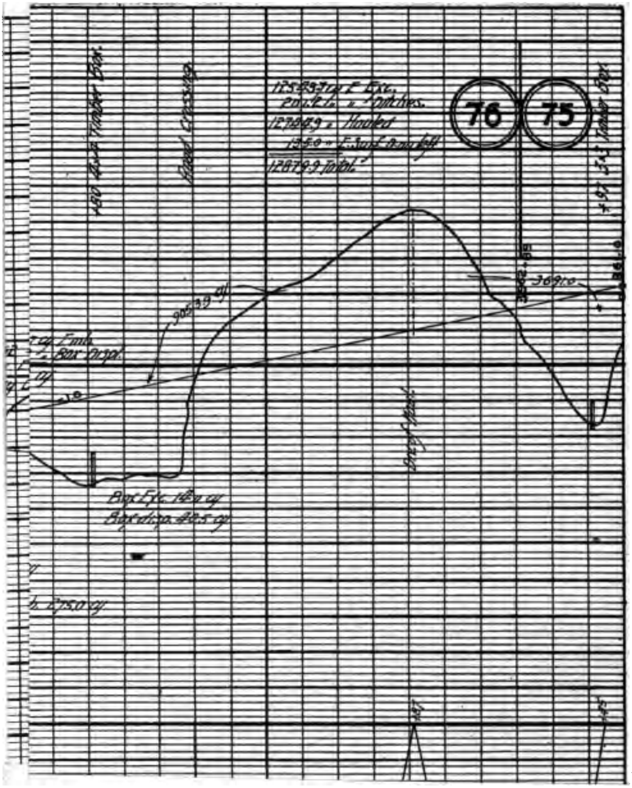
As none of this material was placed in the fill at station 4010, but went on through the cut next east and into that part of the embankment next adjoining that part of the fill made from the cut, station 4004 + to 4008 +. Draw the horizontal line E. S., the point S. being at the station and plus of the west end of the material in the cut, station 4008 + 38, that went into the fill, station 4000, and, of course, made the embankment next adjoining this cut. Continuing as before, adding the cubic yards in each successive station, we obtain the points F. G. H. and I.; through these points plot the "haul curve," obtaining 5733.5 c. y. at I.

By bisecting the quantities in this last cut, we obtain the center of bulk on the "haul curve" just plotted.

Of this last excavation plotted, there is as noted before, in the cut and sub-grade 782.2 c. y. of solid rock, which, for the purpose of illustration in this example, we will consider as swelling 50 per cent or 391 c. y.; plot this 391.1 c. y. vertically below the grade point, I. J., giving sufficient material passing out of the mouth of the cut to make 6124.6 c. y. of embankment. From this quantity deduct the embankment between the grade

points and station 4, and plot the point K., in like manner (deducting all berm ditches and other quantities that have been placed in embankment, taking into account only such embankment quantities as are made with the material hauled from the cuts and of which the haul is being plotted) find the succeeding points K. L. M. N. and O., and plot through them the "haul curve."

Draw the horizontal line E. S. Q. T. which of course intersects the embankment portion of the "haul curve" at a station to which the material from the adjoining cut made the embankment, and the vertical Q. J. represents the quantities in embankment and Q. I. the quantities in excavation; bisect the vertical for the excavation and embankment quantity separately and from the point of bisection draw horizontal lines to the respective "haul curve," which they will intersect at the centers of bulk. These horizontal lines carefully scaled with a 400 feet scale give the total length of average haul, which, less 500 feet free haul, multiplied by the cubic yards hauled, gives the number of pay cubic yards hauled 100 feet. In this case, however, the distance between the centers of bulk is but 490 feet or within the free haul. The material, however, hauled from the west cut was hauled more than 500 feet and the pay haul on which is to be determined as follows: Bisect the vertical line.....at station 4011+18 (which represents the quantities in the west cut hauled out last), and through the point of bisection draw the horizontal line P. R. which will intersect the "haul curve" at the centers of bulk of the excavation and embankment quantities. This horizontal line scaled


76
75
Road Crossing
Timber Box

as before gives the total haul, or 25,181 c. y. hauled 100 feet.

In computing and plotting haul each cut hauled must be considered by itself, as shown in this example; in other words, the haul must be estimated separately for each cut. All haul must be paid for on the mile from which it is secured.

STANDARD GENERAL SPECIFICATIONS.

REVISED, OCTOBER, 1900.

SPECIFICATIONS FOR GRADUATION.

1. **Graduation.**—Graduation shall include all excavations and embankments required for the formation of the roadbed, depot grounds, necessary spurs, yard tracks and sidings, changing direction of streams or channels, the excavation of embankment required in highways or private road crossings, the cutting of all ditches and drains, the excavation for the foundation of all culverts and foundation pits above water, and all other excavations and embankments in any way connected with, or incident to, the construction of the railroad or the grading contracted for.

The right to change, at any time, the alignment or adjustment of the grades of the road, to increase or diminish the width of cuts and embankments, or change their slopes, is reserved to the Engineer, and it is understood that no claim for damages will be made, or allowed, because of such changes.

All work shall be done in a neat and workmanlike manner, and at all times subject to the direction and supervision of the Engineer.

2. **Clearing and Grubbing.**—The surface of the ground is to be cleaned the entire width of the right of way of all brush, trees, logs, grubs, or other perishable material, which are to be removed, *or burned,* as the Engineer may direct, and all dangerous or leaning trees are to be cut down and removed when required by the Engineer.

All roots, stumps and grubs must be removed to a depth of at least two (2) feet below the surface in embankments of less than two feet in height, and for a distance of six (6) feet outside of the slope stakes. Under embankments of more than two feet in height all stumps must be sawed even with the surface, and none must be left on the right of way more than six inches above the surface. Borrow pits must also be grubbed.

3. **Roadbed.**—*Excavation in earth* shall be taken out to a width of..... feet, with slopes one (1) horizontal to one (1) vertical.

Excavations in rock shall be taken out..... feet base, with slopes of one-quarter ($\frac{1}{4}$) horizontal to one (1) vertical.

Embankments of earth shall be .....feet roadbed, with slopes of one and a half ($1\frac{1}{2}$) horizontal to one (1) vertical.

Embankments of rock shall generally be..... feet roadbed, with slopes of three-quarter ($\frac{3}{4}$) horizontal to one (1) vertical.

Embankments of loose rock shall generally be made

with ..... feet roadbed, with slopes of one (1) foot horizontal to one (1) foot vertical.

Surface and berm ditches shall be of the width and character directed by the Engineer, and shall have slopes generally of one (1) horizontal to one (1) vertical.

The ratios of these slopes may be changed at the discretion of the Engineer.

4. Excavation.—Material from all excavations shall be deposited in embankment. The embankments shall be constructed from the material taken from the excavations or cuts, but if the amount of the excavation shall be insufficient to make the embankment, the necessary material shall be obtained by uniformly widening the cuts to such a width as may be determined and directed by the Engineer. If, after all the material has been taken from the cuts, and is still insufficient to make the embankment, the balance of the material may be borrowed, and shall be paid for as earth excavation, whether measured in the borrow pits or in the embankment.

If necessary to waste material from excavation, it shall be hauled off and wasted on either, or both sides of the embankments, or in such places below grade as the Engineer may direct.

Should it become *absolutely* necessary to waste outside of the slope stakes (which, however, shall only be done upon the written permission of the Engineer), the waste or spoil banks shall not be made within ten (10) feet of the slope stakes, or within three (3) feet of the property lines.

In rock excavation, material shall be taken out one

(1) foot below sub-grade, and filled in again to sub-grade line with selected material for roadbed.

The use of improper material obtained from below grade, or ditches, for this purpose will not be permitted.

This back filling will be paid for as earth excavation.

In all roadbed excavations, all projections inside of the cross-sectioned prisms shall be removed, and the slopes cleaned down to the solid material. All material loose or liable to fall shall be removed.

The roadbed in cuts and the size and form of side ditches shall be made as directed by the Engineer, or as shown on the plans.

Surface ditches, to prevent surface drainage from running over or against slopes of all cuts, shall be made as directed by the Engineer, and in advance of opening the cut, and paid for the same as other excavations.

Rock, coal, or other valuable material taken from excavations shall be removed, for the use and ownership of the Railroad Company, to such place as the Engineer may direct.

All material from creek beds, change of channels, berm ditches, foundation pits, etc., shall be placed in embankment.

Where embankments are made on side hill, steps shall be cut or plowed in slopes of the natural ground as selected by the Engineer; and whenever directed by the Engineer, wet and boggy material shall be excavated from under proposed embankment, and the embankment started from a firm foundation.

5. **Embankments.**—Embankments shall be made from the excavated material as heretofore specified,

and, as far as possible, started at the base, the full width indicated by the slope stakes, and built to the true slope in horizontal layers not exceeding four (4) feet in thickness, and where there is a choice of material, the best shall be used on top of the embankment, for at least two (2) feet in depth.

The Engineer may require that so much more earth as may be needed to maintain the banks to profile grade shall be put upon slopes and top of bank. This amount will be fixed by said Engineer, but is not to be paid for, being only allowance for shrinkage.

6. Borrow Pits and Berms.—Borrow pits, where used, shall be confined to such limits as the Engineer may direct, and in case the area of the borrow pit shall exceed the Railroad Company's property or right of way, the contractor shall procure the land necessary. In all cases a berm of not less than ten (10) feet in width shall be left outside of the foot of any embankment slope, and one of not less than three (3) feet inside of the right of way lines.

Side slopes of borrow pits shall be one and a half ($1\frac{1}{2}$) horizontal to one (1) vertical.

Borrow pits must be uniform in width and excavated in a regular form as a ditch, with the bottoms of sufficient grade so that they will drain themselves to the first bridge or culvert, or one to another.

The bottom of borrow pits near bridge or culvert shall not be excavated below the surface over which the water runs through the opening, so that they will drain themselves thoroughly; they shall be left neat and regular, and not disfigure the land unnecesarily.

Borrow pits will not be allowed in or around depot grounds.

No classification whatever will be allowed in borrow pits, *unless specific instructions are given by the Chief Engineer in writing*, it being the intent of these specifications that *all borrowed material shall be classified as earth excavation.*

Should it become *necessary* at any time to borrow any rock excavation, and it is found impracticable to measure the material in the borrow pit, the fill will be measured, with the following allowance: Two-thirds ($\frac{2}{3}$) of a yard in excavation equal to one (1) yard in embankment.

7. Classification.—Material shall be classified only as SOLID ROCK, LOOSE ROCK and EARTH.

Solid Rock.—Shall include all rock in masses, or ledges, in their original or stratified bed, or position, and boulders and detached masses of rock exceeding one cubic yard in measurement.

Loose Rock.—Shall include all shale, slate, soapstone, cemented gravel and hard pan, and all boulders and detached rock exceeding two cubic feet and less than one cubic yard.

Earth.—Shall include all loam, clay, sand, gravel, and all other materials which are not included in the above specifications of loose or solid rock.

Whenever the quantities of the classified material cannot be accurately measured, it will be classified by the Chief Engineer on a percentage basis, and his decision in this regard will be final and conclusive.

8. Measurements and Estimates.—Payments will be made on the following unit prices:

Grubbing and Clearing, per acre.....
Earth Excavation, per cubic yard.....
Loose Rock Excavation, per cubic yard.....
Solid Rock Excavation, per cubic yard.....
Overhaul, for each station of one hundred (100) feet beyond first five hundred (500) feet free haul, per cubic yard.....

Clearing and Grubbing will be paid for by the acre, and the one price per acre shall include both clearing and grubbing and the felling and removal of all dangerous and leaning trees contiguous to the right of way.

Solid Rock, Loose Rock, and Earth shall, as far as possible, be measured in excavation, and be paid for by the cubic yard of twenty-seven (27) cubic feet. If the borrow pits, however, are taken out in such shape as to render actual measurements impracticable, then the material so borrowed shall be measured in the embankment, using the cross-section notes of the embankment prism. Material so measured shall be paid for as earth excavation.

No material, in any case, shall be paid for twice, *i. e.*, in excavations and embankments both.

9. **Hauling Material.**—The price per cubic yard shall include the material hauled a distance of not exceeding five hundred feet, and for that necessarily hauled a greater distance, whether from cuts or borrow pits, an additional price per cubic yard, for each one hundred feet hauled after the first five hundred, will be paid.

The haul shall not be limited by any bridge or opening, across or around which a reasonable load can be hauled.

The distance of paid haul shall be determined by computing the centers of bulk and deducting five hundred feet therefrom.

10. Crossings and Gates.—Whenever the route of the railroad is traversed or crossed by public or private roads, safe and commodious crossings must be made and kept open for use, and in passing through farms the contractor shall also keep up such temporary fences or gates as may be necessary for the preservation of crops or to prevent injury to lands.

SPECIFICATIONS FOR MASONRY.

All work shall be done in the most substantial and workmanlike manner and subject to the directions of the Engineer, and all materials shall be subject to his approval and inspection.

All stone used shall be sound and durable, free from "drys" or seams; not liable to be affected by the weather, and shall be laid upon their natural beds, the large stones being selected for foundations.

All cement shall be an approved brand, newly manufactured and subject to the test desired by the Chief Engineer.

Cement mortar shall in general be composed of two parts of sand to one of cement, and shall be used immediately after mixing.

All sand used in mortar shall be clean and sharp.

Much importance will be attached to the cement mortar; the very best will be required, and its liberal use insisted upon.

All masonry laid in cement mortar shall be neatly pointed, before being accepted, with mortar composed of one part Portland cement to one part sand.

None but skilled stone-cutters and masons are to be employed on the masonry.

11. **Classification.**—Masonry and other classes of work usually connected therewith, and for which prices will be paid, are classified as follows:

First-class Masonry. Second-class Masonry. Rubble Masonry Laid in Cement. Rubble Masonry Laid Dry. Rip-rap. Paving and Slope Wall. Excavation Under Water. Piles in Foundations. Timber in Foundations.

12. **Measurements and Estimates.**—All masonry and excavations for foundations shall be estimated and paid for by the cubic yard. Timber in foundations, by the 1,000 feet, B. M. Piles in foundations, by the lineal foot. Iron included in the above prices per M. for timber.

The price for the above classes of work shall include every and all expense incurred in the construction of masonry structures; such, for example, as the building of coffer-dams; bailing and pumping of water; the furnishing of material and transportation of materials, unless otherwise contracted; the cost of all scaffolding, concrete forms and centers; the placing and removal of same; the preparation and maintenance of all roads that may be required in transporting materials to the work, etc., as well as the actual workmanship.

13. **First-class Masonry.**—Under this head will come generally bridge abutments and piers of the larger class, and arch culverts of the greater span than ten feet; this

class of masonry shall be laid in cement mortar, in regular courses, each stone being carefully cleaned and dampened before setting.

The face stone shall be "rock faced" with edges pitched to a straight line and no projections exceeding six inches; the beds throughout, and the joints for twelve inches back from the face, shall be dressed to three-eighths of an inch, and draft lines two inches wide shall be cut at each angle in the masonry.

No course shall be less than twelve inches thick, and the thickness of no course shall be greater than that of the next course below it; no stone shall be cut in the wall; there shall be at least one header to every two stretchers; each stretcher shall be not less than two and one-half feet nor more than six feet long, nor less in width than one and one-half times its thickness; each header shall be at least three and one-half feet long, and not less than one and one-half feet wide.

The stones of each course must break joints at least one foot with those below, and the headers must be so distributed as to secure the best possible bond.

Each stone must be set upon a full bed of fresh mortar, the broadest bed down, and brought to a firm and level bearing, without spawls or pinners; joints shall be packed full of mortar, and their faces afterwards cleaned.

The backing stone shall be of suitable size, not less than twelve inches thick, and laid in full mortar beds without spawls or pinners, breaking joints with one another and with the face stone, and no more small stone and spawls shall be used than is necessary to fill up the unavoidable spaces around the large stones, and

upon the completion of each course the whole shall be thoroughly grouted.

The coping shall be formed of large flat stones, which shall extend entirely across the wall when the same is not more than six feet wide, and no coping shall be less than sixteen inches in thickness. The steps of wing walls shall be capped with stone, covering the entire step, and extending under the next step above at least twelve inches thick, and have such projections as the Engineer may direct, and shall have their tops and faces bush-hammered, and the joints and beds cut to one-quarter inch throughout.

Arch stones shall have beds and joints cut to three-eighths of an inch, and conforming to the radius of the arch; each stone shall extend through the arch and break joints at least one foot, and when backing is used, headers shall be so arranged in the sheathing that the backing can be bonded thereto, to give the greatest strength to the arch. The ring stones shall be laid as headers and stretchers, alternating, and be of sufficient length and so laid as to be bonded strongly with the rest of the arch.

The whole top of the arch is to be plastered with a good coat of cement mortar so as to shed water.

14. **Second-class Masonry.**—Under this head will come generally piers and abutments of the lighter class, and when so designated, arch culverts of ten-foot span and under. This class of masonry shall be laid in cement mortar. The face stone shall have rock faces with edges pitched to a straight line; each stone shall be dressed to a uniform thickness, with beds throughout, and joints for eight inches back from the face,

dressed to one-half inch. Stone need not be laid up in regular courses, but shall be well bonded, having at least one header three feet long to every three stretchers. No stone should be less than eight inches thick, and no stone shall measure in its least horizontal dimensions less than twelve inches, nor less than its thickness.

The stone shall be laid in full mortar beds, the joints packed full and cleaned.

The packing shall consist of stone not less than six inches thick; at least one-half shall measure two cubic feet, and all shall be laid in full mortar beds and grouted, or the spaces filled with cement mortar.

The coping shall be formed of large, flat stones not less than twelve inches in thickness, with the upper surface bush-hammered, and joints and beds dressed to one-half an inch throughout; each stone must extend entirely across the wall when the wall is not more than five (5) feet thick.

Except in the above-mentioned particulars the specifications for First-class Masonry will apply to Second-class Masonry.

15. Rubble Masonry in Cement.—Under this head will come generally box or open culverts, foundations for buildings, small arch culverts, etc., and where so designated the smaller size of bridge abutments, piers and arch culverts of six and eight-foot span. This class of masonry will be laid in cement mortar, and will be broken range rubble of good quality; no stone shall be less than six inches in thickness, unless otherwise directed by the Engineer; no stone shall measure less than twelve inches in its least horizontal dimensions or less than its thickness. At least one-fourth of the stone

in the face are to be headers, evenly distributed throughout the wall; stone shall be roughly squared on joints, beds and faces, laid so as to break joints, and in full mortar beds, all to be well grouted, or spaces flushed and packed full of cement mortar. Selected stones shall be used at all angles, and shall be neatly pitched to true lines and laid on hammer-dressed beds; draft lines may be required at the more prominent angles. The top of parapet walls, piers and abutments shall be capped with stone extending entirely across the wall, and having a front end projection of not less than four inches; coping stone shall be neatly squared, and laid with joints not less than one-half inch.

The steps of wing walls shall be capped with stone covering the entire step, and extending at least six inches into the wall.

Coping and step stones shall be roughly hammer-dressed on top, their outer faces pitched to true lines, and to be of such thickness (not less than ten inches), and have such projections, as the Engineer may direct.

In the walls of box culverts at least each alternate top stone shall extend entirely across the wall, and covering stone shall reach onto each wall not less than ten inches, and in thickness shall not be less than three-tenths of the clear span of the culvert, and shall be laid with close cemented joints. In arch culverts ring stones shall be dressed to one-half inch joints, with beds conforming to the radius of arch. The sheathing shall be of carefully selected stone, of uniform thickness and quality, and each stone shall extend entirely through the arch, breaking joints not less than six inches, and be not less than four inches wide at the intrados. The

exterior of the arch shall be surfaced by plastering with cement mortar, so as to shed water.

16. **Rubble Masonry Laid Dry.**—This class of masonry, as a rule, will be used only in the smaller box culverts and in retaining walls. The specifications for rubble masonry laid in cement will generally apply to this, except as to the use of cement mortar.

17. **Paving.**—This, where required, will be made of flat stones from ten to twelve inches in depth, set on their edges, closely laid and well bedded, and presenting an even top surface. Paving will be paid for as "paving and slope wall."

18. **Rip-rap.**—Rip-rap shall consist of a covering of durable, fair-sized stone, placed promiscuously to depth required; the character and size of the stone, and the depth to which the same are to be placed, shall be determined by the Engineer in charge. No material within regular prism of embankment shall be paid for as rip-rap.

19. **Slope Wall.**—Will be made from rock of such quality and dimensions as is approved by the Engineer in charge. The wall will generally be laid one (1) foot to one and one-half ($1\frac{1}{2}$) feet thick, and the foundation must be laid in accordance with the stakes of the Engineer of the company, or, as by him directed. The stones shall be laid with their beds at right angles to the plane of the slope to be protected.

The work shall be well bonded, and present a reasonably true and smooth surface, free from holes or projections that would endanger the wall from floating driftwood.

20. **Any Stone** used in rip-rap, slope walls or other

masonry, which has been obtained from excavations or cuts on the railroad under construction, and been previously paid for as grading, will be allowed for at a unit price equal to the difference between rock graduation and the masonry item wherein such stone is used.

21. **All Structures** shall be built in conformity with plans to be furnished from time to time by the Chief Engineer and in accordance with the direction of the Engineer, and such plans and directions shall be complied with in every respect, and shall be considered a part of these specifications.

22. **Concrete.**—Concrete piers, abutments, culverts, etc., shall generally be composed of one part of Portland cement, two parts sand and four parts broken stone, built in forms neatly made and true to dimensions, with the timber next to the concrete surfaced or planed. The concrete must be mixed on a platform of boards, the sand to be spread first and then the cement, both mixed dry; then water will be added, the mixture being constantly mixed with hoe or shovel from end to end until the proper consistency is attained. Broken stone will then be added, after having previously been wetted, and the whole mass thoroughly mixed from end to end and turned at least three times before placing. After taking the concrete from the boards, extreme care will be demanded in depositing the same in uniform layers of not exceeding eight (8) inches in thickness, well tamped with wooden tamps. Care must be used that no dirt or foreign substance becomes mixed in the concrete.

The most rigid inspection will be made of this class of work, and the Contractor required to fully carry out the Engineer's instructions.

23. Cement used in the work shall be subject to tests required by the Chief Engineer, and no cement must be used in the work until tested and the brand approved, in writing, by the Chief Engineer. Cement must be delivered to the work in cooperage.

24. Sand to be used in the mortar, concrete or grout must be sharp, clear and free from dust or dirt or foreign substances, and if not obtained from natural beds must be screened and washed.

25. Stone used in concrete work shall be of the hardest quality obtainable, and subject to the approval of the Engineer. Stone shall be broken to pass through a 2½ inch ring, and handled exclusively with forked shovels to keep the stone free from dirt.

SPECIFICATIONS FOR LUMBER.

26. Timber and Planks in foundations, culverts, cattle guards, trestle work, bridge abutments, cattle passes and road crossings, pile and frame bridges, shall be of good quality, according to specifications, and shall be measured by the one thousand feet, board measure, and the price per thousand feet shall cover all expenses of material in place, including iron, and the excavation and refilling of bank ends at bank bents of frame and pile bridges.

27. Piles, whether used in foundations, trestle work or pile bridges, shall be of good, sound quality white oak, burr oak, long-leaf pine, or such other timber as the Chief Engineer may direct, not less than ten (10) inches in diameter at the smallest end, and fourteen

(14) inches at long end, of such length billed, or as the Engineer may require, and all the bark shall be removed before being placed in the work. Piles shall be driven with a hammer weighing not less than 2,400 pounds, through a height of lead of not less than thirty-five feet, and driven to a refusal with hammer, falling the full length of leads. The outside piles must invariably be driven to a batter of 1 in 8. Whenever required, piles must be properly shoed, and no extra allowance will be made therefor. Piles will be paid for by the lineal foot billed or in the leads.

28. Long-leaf Yellow Pine.—Timber to be well and truly manufactured, and have straight edges entire clear of wane; must be sound and all heart, except 1½ inches of sap on corners of a 10x12 or 8x16 piece. To be clear of large knots and wind shakes that depreciate the strength of the timbers.

29. Oak.—To be well and truly manufactured with straight edges, of white, post or burr oak cut from prime native trees, and free from all shakes and loose knots.

30. Native Pine.—Stock to be well and truly manufactured, full to sizes except as herein provided, and sawed butted; free from sap, large and unsound knots, shakes and splits through or around, and must show heart on each face. It may show wane on two corners and not exceeding eighteen inches in each 12 feet in length, and sap two inches wide on corners of a 10x10 stick, and wider in proportion on larger sizes.

Contractor must consult standard plans in connection with these specifications.

ABSTRACT

FROM

GENERAL FORM OF CONTRACT.

REVISED FEBRUARY, 1901.

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3. The Contractor takes the work embraced in this contract solely upon his own information and judgment of the character and topography of the country, its streams, water courses and rainfall, and subject to the same, and the location and amount of the various kinds of materials to be encountered, and without reliance upon the profile and preliminary approximate estimates of the Chief Engineer of the Company.

6. Whenever work is required to be done which is not covered by the prices herein mentioned, the Chief Engineer of the Company shall give a written order for the doing of such work and fix the prices to be paid for the doing of the same. The obtaining of the certificate of the Chief Engineer of the Company as to such extra work done and the price thereof shall be a condition precedent to the right of the Contractor to be paid for any such extra work; *Provided,*

That nothing shall be deemed extra work, however, which can be measured or estimated under the provisions of this contract; and, *Provided further,*

That all claims for extra work or material must be presented to the Chief Engineer of the Company, for allowance, at the close of the month in which it was done or furnished, in order that it may be paid for in that month; otherwise all claims therefor shall be deemed absolutely waived by the Contractor, and the Company shall not be required to allow or pay for the same.

8. The work shall be performed under the personal supervision of the Contractor, and this contract shall not be assigned, nor any portion of the work be sub-contracted, to any person or sub-contractor not acceptable to the Chief Engineer of the Company. All sub contracts shall be on forms approved by the Chief Engineer, and shall be executed in triplicate and delivered to the Chief Engineer of the Company, and he shall indorse his written assent to the same in writing thereon, and keep one on file in his office and return the others to the contractor; and no sub-contractor shall be allowed to commence work on any portion of said line until such sub-contracts are approved by the Chief Engineer and one of the the same filed in his office, as above provided.

10. The Contractor shall, at his own proper cost and expense, make and keep open, and in safe condition for use, all crossings and approaches wherever the line of railway is traversed by, or is adjacent to, public or private roads or farm crossings, and shall change and alter said roads, approaches and crossings whenever required by the Chief Engineer of the Company, during the construction of the line.

11. The Contractor shall be responsible for all dam-

ages of every nature whatsoever done to persons or property during the performance of the work by the Contractor, or by any of his sub-contractors, foremen, laborers or other employees or agents; and the Contractor shall, at his own proper cost and expense, make and maintain such temporary provision as may be necessary by way of fences or otherwise for the protection of persons and property during the performance of said work.

12. All roads to quarries, quarry leaves, roads for hauling materials, and ways to and from the work, together with all grounds for the deposit of materials and the erection of shanties or yards for the performance of the work, not within the limits of the Company's lands, shall be provided by the Contractor at his own proper cost and expense.

14. The Contractor shall be at the risk of, and shall bear all loss or damage which may occur on the work or any part thereof, until the same be fully and finally completed and delivered to and accepted by the Company, and if any loss or damage occur before such final completion, delivery and acceptance, the Contractor shall immediately repair and restore, at his own expense, the work so damaged, so that the whole work and each and every part thereof may be completed within the time herein limited, and may be in good order and condition at the time the same is presented for acceptance.

15. All imperfect or insufficient work or material, when pointed out by the Chief Engineer of the Company, shall be immediately remedied and made good and sufficient by the Contractor, at his own cost and

expense, to the satisfaction of said Chief Engineer, and any omission by the said Chief Engineer to disapprove of or reject any insufficient or imperfect work or material at the time of any monthly or other estimate, shall not be deemed an acceptance of such work or material; and the said Chief Engineer shall have the power to have any defective work and material taken out and rebuilt or replaced at any time at the expense of the Contractor.

The approximate estimates made from month to month shall not, in any respect, be taken as an admission by the Company of the correct measurement or classification of the work done, or of its quality or sufficiency, or of the amount due the Contractor, nor as an acceptance of the work or release of the Contractor from responsibility in respect thereof; but, at the time of the making of the final estimate, the whole of the work and all of the particulars relating thereto, including quantity, classification and price, shall be subject to revision and adjustment by the Chief Engineer of the Company, and no estimate, except the final estimate, shall be any evidence of the correct quantities, classification, measurements, or amount due the Contractor. Nor shall the Company be liable for any errors or omissions in said approximate monthly estimates, nor for any loss or damage suffered by the Contractor by reason of his having settled with his sub-contractors on the faith thereof, or otherwise.

And the Chief Engineer of the Company, who may be such at any time during the performance of this contract, is hereby expressly authorized by the Company to appoint all necessary assistant, resident and division

engineers and other agents to represent him upon the work or in and about the same, and to vest in them, or any or either of them, any or all of the powers conferred upon him herein, or in the annexed specifications, and all directions given by assistant engineers, inspectors or other persons appointed by the Chief Engineer during the construction of the work covered by this contract, must be as fully and explicitly carried out as if directed by the Chief Engineer personally. Said Chief Engineer may take final action as umpire, upon any and all questions, matters and things arising under this contract, upon the reports and statements of said assistant, resident or division engineers or other agents, without notice to the parties hereto, or personal inspection of the work, and all of his acts in the premises shall be final and conclusive and binding upon the parties to this contract.

TABLES OF

LEVEL CUTTINGS.

PRISMOIDS 100 FEET LONG.

To be Used for Preliminary Work Only.

TABLE NO. 1.—EXCAVATION AND EMBANKMENT.

CUBIC YARDS.

Prismoids 100 feet long. Slopes 1½ Horizontal to 1 Perpendicular. Breadth of Base 12 feet.

Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards
0.0	0.0	2.0	111.1	4.0	266.7	6.0	466.7	8.0	711.1
.1	4.5	.1	117.8	.1	275.6	.1	477.8	.1	724.5
.2	9.1	.2	124.7	.2	284.7	.2	489.1	.2	738.0
.3	13.8	.3	131.6	.3	293.8	.3	500.5	.3	751.6
.4	18.7	.4	138.7	.4	303.1	.4	512.0	.4	765.3
.5	23.6	.5	145.8	.5	312.5	.5	523.6	.5	779.2
.6	28.7	.6	153.1	.6	322.0	.6	535.3	.6	793.1
.7	33.8	.7	160.5	.7	331.6	.7	547.2	.7	807.2
.8	39.1	.8	168.0	.8	341.3	.8	559.1	.8	821.3
.9	44.5	.9	175.6	.9	351.2	.9	571.2	.9	835.6
1.0	50.0	3.0	183.3	5.0	361.1	7.0	583.3	9.0	850.0
.1	55.6	.1	191.2	.1	371.2	.1	595.6	.1	864.5
.2	61.3	.2	199.1	.2	381.3	.2	608.0	.2	879.1
.3	67.2	.3	207.2	.3	391.6	.3	620.5	.3	893.8
.4	73.1	.4	215.3	.4	402.0	.4	633.1	.4	908.7
.5	79.2	.5	223.6	.5	412.5	.5	645.8	.5	923.6
.6	85.3	.6	232.0	.6	423.1	.6	658.7	.6	938.7
.7	91.6	.7	240.5	.7	433.8	.7	671.6	.7	953.8
.8	98.0	.8	249.1	.8	444.7	.8	684.7	.8	969.1
.9	104.5	.9	257.8	.9	455.6	.9	697.8	.9	984.5

TABLE NO. 1—*Continued.*

Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards
10.0	1000.0	12.0	1333.3	14.0	1711.1	16.0	2133.3	20.0	3111.1
.1	1015.6	.1	1351.2	.1	1731.2	.1	2155.6	21.0	3383.3
.2	1031.3	.2	1369.1	.2	1751.3	.2	2178.0	22.0	3666.7
.3	1047.2	.3	1387.2	.3	1771.6	.3	2200.5	23.0	3961.1
.4	1063.1	.4	1405.3	.4	1792.0	.4	2223.1	24.0	4266.7
.5	1079.2	.5	1423.6	.5	1812.5	.5	2245.8	25.0	4583.3
.6	1095.3	.6	1442.0	.6	1833.1	.6	2268.7	26.0	4911.1
.7	1111.6	.7	1460.5	.7	1853.8	.7	2291.6	27.0	5250.0
.8	1128.0	.8	1479.1	.8	1874.7	.8	2314.7	28.0	5600.0
.9	1144.5	.9	1497.8	.9	1895.6	.9	2337.8	29.0	5961.1
11.0	1161.1	13.0	1516.7	15.0	1916.7	17.0	2361.1	30.0	6333.3
.1	1177.8	.1	1535.6	.1	1937.8	.1	2384.5	31.0	6716.7
.2	1194.7	.2	1554.7	.2	1959.1	.2	2408.0	32.0	7111.1
.3	1211.6	.3	1573.8	.3	1980.5	.3	2431.6	33.0	7516.7
.4	1228.7	.4	1593.1	.4	2002.0	.4	2455.3	34.0	7933.3
.5	1245.8	.5	1612.5	.5	2023.6	.5	2479.2	35.0	8361.1
.6	1263.1	.6	1632.0	.6	2045.3	.6	2503.1	36.0	8800.0
.7	1280.5	.7	1651.6	.7	2067.2	.7	2527.2	37.0	9250.0
.8	1298.0	.8	1671.3	.8	2089.1	18.0	2600.0	38.0	9711.1
.9	1315.6	.9	1691.2	.9	2111.2	19.0	2850.0	39.0	10183.3

TABLE NO. 2.—EXCAVATION AND EMBANKMENT.

CUBIC YARDS.

Prismoids 100 feet long. Slopes 1½ Horizontal to 1 Perpendicular. Breadth of Base 14 feet.

Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards
0.0	0.0	2.0	125.9	4.0	296.3	6.0	511.1	8.0	770.4
.1	5.2	.1	133.4	.1	306.0	.1	523.0	.1	784.5
.2	10.6	.2	141.0	.2	315.8	.2	535.0	.2	798.7
.3	16.1	.3	148.6	.3	325.7	.3	547.2	.3	813.1
.4	21.6	.4	156.4	.4	335.7	.4	559.4	.4	827.6
.5	27.3	.5	164.4	.5	345.8	.5	571.8	.5	842.1
.6	33.1	.6	172.4	.6	356.1	.6	584.2	.6	856.8
.7	39.0	.7	180.5	.7	366.4	.7	596.8	.7	871.6
.8	45.0	.8	188.7	.8	376.9	.8	609.5	.8	886.5
.9	51.2	.9	197.1	.9	387.5	.9	622.3	.9	901.5
1.0	57.4	3.0	205.6	5.0	398.1	7.0	635.2	9.0	916.7
.1	63.8	.1	214.1	.1	408.9	.1	648.2	.1	931.9
.2	70.2	.2	222.8	.2	419.9	.2	661.3	.2	947.3
.3	76.8	.3	231.6	.3	430.9	.3	674.6	.3	962.7
.4	83.5	.4	240.5	.4	442.0	.4	687.9	.4	978.3
.5	90.3	.5	249.5	.5	453.2	.5	701.4	.5	994.0
.6	97.2	.6	258.7	.6	464.6	.6	715.0	.6	1009.8
.7	104.2	.7	267.9	.7	476.1	.7	728.6	.7	1025.7
.8	111.3	.8	277.3	.8	487.6	.8	742.4	.8	1041.7
.9	118.6	.9	286.7	.9	499.3	.9	756.4	.9	1057.8

TABLE NO. 2—*Continued.*

Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards
10.0	1074.1	12.0	1422.2	14.0	1814.8	16.0	2251.9	20.0	3259.3
.1	1090.4	.1	1440.8	.1	1835.6	.1	2274.9	21.0	3538.9
.2	1106.9	.2	1459.5	.2	1856.5	.2	2298.0	22.0	3829.6
.3	1123.5	.3	1478.3	.3	1877.5	.3	2321.2	23.0	4131.5
.4	1140.1	.4	1497.2	.4	1898.7	.4	2344.6	24.0	4444.4
.5	1156.9	.5	1516.2	.5	1919.9	.5	2368.1	25.0	4768.5
.6	1173.9	.6	1535.3	.6	1941.3	.6	2391.6	26.0	5103.7
.7	1190.9	.7	1554.6	.7	1962.7	.7	2415.3	27.0	5450.0
.8	1208.0	.8	1573.9	.8	1984.3	.8	2439.1	28.0	5807.4
.9	1225.2	.9	1593.4	.9	2006.0	.9	2463.0	29.0	6175.9
11.0	1242.6	13.0	1613.0	15.0	2027.8	17.0	2487.0	30.0	6555.6
.1	1260.1	.1	1632.6	.1	2049.7	.1	2511.2	31.0	6946.3
.2	1277.6	.2	1652.4	.2	2071.7	.2	2535.4	32.0	7348.1
.3	1295.3	.3	1672.4	.3	2093.8	.3	2559.8	33.0	7761.1
.4	1313.1	.4	1692.4	.4	2116.1	.4	2584.2	34.0	8185.2
.5	1331.0	.5	1712.5	.5	2138.4	.5	2608.8	35.0	8620.4
.6	1349.0	.6	1732.7	.6	2160.9	.6	2633.5	36.0	9066.7
.7	1367.2	.7	1753.1	.7	2183.5	.7	2658.3	37.0	9524.1
.8	1385.4	.8	1773.6	.8	2206.1	18.0	2733.3	38.0	9992.6
.9	1403.8	.9	1794.1	.9	2228.9	19.0	2990.7	39.0	10472.2

TABLE NO. 3.—EXCAVATION AND EMBANKMENT.

CUBIC YARDS.

Prismoids 100 feet long. Slopes 1½ Horizontal to 1 Perpendicular. Breadth of Base 15 feet.

Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards
0.0	0.0	2.0	133.3	4.0	311.1	6.0	533.3	8.0	800.0
.1	5.6	.1	141.2	.1	321.2	.1	545.6	.1	814.5
.2	11.3	.2	149.1	.2	331.3	.2	558.0	.2	829.1
.3	17.2	.3	157.2	.3	341.6	.3	570.5	.3	843.8
.4	23.1	.4	165.3	.4	352.0	.4	583.1	.4	858.7
.5	29.2	.5	173.6	.5	362.5	.5	595.8	.5	873.6
.6	35.3	.6	182.0	.6	373.1	.6	608.7	.6	888.7
.7	41.6	.7	190.5	.7	383.8	.7	621.6	.7	903.8
.8	48.0	.8	199.1	.8	394.7	.8	634.7	.8	919.1
.9	54.5	.9	207.8	.9	405.6	.9	647.8	.9	934.5
1.0	61.1	3.0	216.7	5.0	416.7	7.0	661.1	9.0	950.0
.1	67.8	.1	225.6	.1	427.8	.1	674.5	.1	965.6
.2	74.7	.2	234.7	.2	439.1	.2	688.0	.2	981.3
.3	81.6	.3	243.8	.3	450.5	.3	701.6	.3	997.2
.4	88.7	.4	253.1	.4	462.0	.4	715.3	.4	1013.1
.5	95.8	.5	262.5	.5	473.6	.5	729.2	.5	1029.2
.6	103.1	.6	272.0	.6	485.3	.6	743.1	.6	1045.3
.7	110.5	.7	281.6	.7	497.2	.7	757.2	.7	1061.6
.8	118.0	.8	291.3	.8	509.1	.8	771.3	.8	1078.0
.9	125.6	.9	301.2	.9	521.2	.9	785.6	.9	1094.5

TABLE NO. 3—*Continued.*

Height	Cubic Yards	Height	Yards Cubic	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards
10.0	1111.1	12.0	1466.7	14.0	1866.7	16.0	2311.1	18.0	2800.0
.1	1127.8	.1	1485.6	.1	1887.8	.1	2334.5	.1	2825.6
.2	1144.7	.2	1504.7	.2	1909.1	.2	2358.0	.2	2851.3
.3	1161.6	.3	1523.8	.3	1930.5	.3	2381.6	.3	2877.2
.4	1178.7	.4	1543.1	.4	1952.0	.4	2405.3	.4	2903.1
.5	1195.8	.5	1562.5	.5	1973.6	.5	2429.2	.5	2929.2
.6	1213.1	.6	1582.0	.6	1995.3	.6	2453.1	.6	2955.3
.7	1230.5	.7	1601.6	.7	2017.2	.7	2477.2	.7	2981.6
.8	1248.0	.8	1621.3	.8	2039.1	.8	2501.3	.8	3008.0
.9	1265.6	.9	1641.2	.9	2061.2	.9	2525.6	.9	3034.5
11.0	1283.3	13.0	1661.1	15.0	2083.3	17.0	2550.0	19.0	3061.1
.1	1301.2	.1	1681.2	.1	2105.6	.1	2574.5	.1	3087.8
.2	1319.1	.2	1701.3	.2	2128.0	.2	2599.1	.2	3114.7
.3	1337.2	.3	1721.6	.3	2150.5	.3	2623.8	.3	3141.6
.4	1355.3	.4	1742.0	.4	2173.1	.4	2648.7	.4	3168.7
.5	1373.6	.5	1762.5	.5	2195.8	.5	2673.6	.5	3195.8
.6	1392.0	.6	1783.1	.6	2218.7	.6	2698.7	.6	3223.1
.7	1410.5	.7	1803.8	.7	2241.6	.7	2723.8	.7	3250.5
.8	1429.1	.8	1824.7	.8	2264.7	.8	2749.1	.8	3278.0
.9	1447.8	.9	1845.6	.9	2287.8	.9	2774.5	.9	3305.6

TABLE NO. 3—*Continued.*

Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards
20.0	3333.3	22.0	3911.1	24.0	4533.3	40.0	11111.1	60.0	23333.3
.1	3361.2	.1	3941.2	.1	4565.6	41.0	11616.7	61.0	24061.1
.2	3389.1	.2	3971.3	.2	4598.0	42.0	12133.3	62.0	24800.0
.3	3417.2	.3	4001.6	.3	4630.5	43.0	12661.1	63.0	25550.0
.4	3445.3	.4	4032.0	.4	4663.1	44.0	13200.0	64.0	26311.1
.5	3473.6	.5	4062.5	25.0	4861.1	45.0	13750.0	65.0	27083.3
.6	3502.0	.6	4093.1	26.0	5200.0	46.0	14311.1	66.0	27866.7
.7	3530.5	.7	4123.8	27.0	5550.0	47.0	14883.3	67.0	28661.1
.8	3559.1	.8	4154.7	28.0	5911.1	48.0	15466.7	68.0	29466.7
.9	3587.8	.9	4185.6	29.0	6283.3	49.0	16061.1	69.0	30283.3
21.0	3616.7	23.0	4216.7	30.0	6666.7	50.0	16666.7	70.0	31111.1
.1	3645.6	.1	4247.8	31.0	7061.1	51.0	17283.3	71.0	31950.0
.2	3674.7	.2	4279.1	32.0	7466.7	52.0	17911.1	72.0	32800.0
.3	3703.8	.3	4310.5	33.0	7883.3	53.0	18550.0	73.0	33661.1
.4	3733.1	.4	4342.0	34.0	8311.1	54.0	19200.0	74.0	34533.3
.5	3762.5	.5	4373.6	35.0	8750.0	55.0	19861.1	75.0	35416.7
.6	3792.0	.6	4405.3	36.0	9200.0	56.0	20533.3	76.0	36311.1
.7	3821.6	.7	4437.2	37.0	9661.1	57.0	21216.7	77.0	37216.7
.8	3851.3	.8	4469.1	38.0	10133.3	58.0	21911.1	78.0	38133.3
.9	3881.2	.9	4501.2	39.0	10616.7	59.0	22616.7	79.0	39061.1

TABLE NO. 4.—EXCAVATION AND EMBANKMENT.

CUBIC YARDS.

Prismoids 100 feet long. Slopes 1½ Horizontal to 1 Perpendicular. Breadth of Base 18 feet.

Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards
0.0	0.0	2.0	155.6	4.0	355.6	6.0	600.0	8.0	888.9
.1	6.7	.1	164.5	.1	366.7	.1	613.4	9.0	1050.0
.2	13.6	.2	173.6	.2	378.0	.2	626.9	10.0	1222.2
.3	20.5	.3	182.7	.3	389.4	.3	640.5	11.0	1405.6
.4	27.6	.4	192.0	.4	400.9	.4	654.2	12.0	1600.0
.5	34.7	.5	201.4	.5	412.5	.5	668.1	13.0	1805.6
.6	42.0	.6	210.9	.6	424.2	.6	682.0	14.0	2022.2
.7	49.4	.7	220.5	.7	436.1	.7	696.1	15.0	2250.0
.8	56.9	.8	230.2	.8	448.0	.8	710.2	16.0	2488.9
.9	64.5	.9	240.1	.9	460.1	.9	724.5	17.0	2738.9
1.0	72.2	3.0	250.0	5.0	472.2	7.0	738.9	18.0	3000.0
.1	80.1	.1	260.1	.1	484.5	.1	753.4	19.0	3272.2
.2	88.0	.2	270.2	.2	496.9	.2	768.0	20.0	3555.6
.3	96.1	.3	280.5	.3	509.4	.3	782.7	21.0	3850.0
.4	104.2	.4	290.9	.4	522.0	.4	797.6	22.0	4155.6
.5	112.5	.5	301.4	.5	534.7	.5	812.5	23.0	4472.2
.6	120.9	.6	312.0	.6	547.6	.6	827.6	24.0	4800.0
.7	129.4	.7	322.7	.7	560.5	.7	842.7	25.0	5138.9
.8	138.0	.8	333.6	.8	573.6	.8	858.0	26.0	5488.9
.9	146.7	.9	344.5	.9	586.7	.9	873.4	27.0	5850.0

TABLE NO. 5.—EXCAVATION AND EMBANKMENT.

CUBIC YARDS.

Prismoids 100 feet long. Slopes 1½ Horizontal to 1 Perpendicular. Breadth of Base 16 feet.

Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards
0.0	0.0	2.0	140.7	4.0	325.9	6.0	555.6	8.0	829.6
.1	6.0	.1	148.9	.1	336.4	.1	568.2	.1	844.5
.2	12.1	.2	157.3	.2	346.9	.2	581.0	.2	859.5
.3	18.3	.3	165.7	.3	357.5	.3	593.8	.3	874.6
.4	24.6	.4	174.2	.4	368.3	.4	606.8	.4	889.8
.5	31.0	.5	182.9	.5	379.2	.5	619.9	.5	905.1
.6	37.6	.6	191.6	.6	390.1	.6	633.1	.6	920.5
.7	44.2	.7	200.5	.7	401.2	.7	646.4	.7	936.1
.8	51.0	.8	209.5	.8	412.4	.8	659.9	.8	951.7
.9	57.8	.9	218.6	.9	423.8	.9	673.4	.9	967.5
1.0	64.8	3.0	227.8	5.0	435.2	7.0	687.0	9.0	983.3
.1	71.9	.1	237.1	.1	446.7	.1	700.8	.1	999.3
.2	79.1	.2	246.5	.2	458.4	.2	714.7	.2	1015.4
.3	86.4	.3	256.1	.3	470.1	.3	728.6	.3	1031.6
.4	93.9	.4	265.7	.4	482.0	.4	742.7	.4	1047.9
.5	101.4	.5	275.5	.5	494.0	.5	756.9	.5	1064.4
.6	109.0	.6	285.3	.6	506.1	.6	771.3	.6	1080.9
.7	116.8	.7	295.3	.7	518.3	.7	785.7	.7	1097.6
.8	124.7	.8	305.4	.8	530.6	.8	800.2	.8	1114.3
.9	132.6	.9	315.6	.9	543.0	.9	814.9	.9	1131.2

TABLE NO. 5—*Continued.*

Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards
10.0	1148.1	12.0	1511.1	14.0	1918.5	16.0	2370.4	20.0	3407.4
.1	1165.2	.1	1530.4	.1	1940.1	.1	2394.1	21.0	3694.4
.2	1182.4	.2	1549.9	.2	1961.7	.2	2418.0	22.0	3992.6
.3	1199.8	.3	1569.4	.3	1983.5	.3	2442.0	23.0	4301.9
.4	1217.2	.4	1589.0	.4	2005.3	.4	2466.1	24.0	4622.2
.5	1234.7	.5	1608.8	.5	2027.3	.5	2490.3	25.0	4953.7
.6	1252.4	.6	1628.7	.6	2049.4	.6	2514.6	26.0	5296.3
.7	1270.1	.7	1648.6	.7	2071.6	.7	2539.0	27.0	5650.0
.8	1288.0	.8	1668.7	.8	2093.9	.8	2563.6	28.0	6014.8
.9	1306.0	.9	1688.9	.9	2116.4	.9	2588.2	29.0	6390.7
11.0	1324.1	13.0	1709.3	15.0	2138.9	17.0	2613.0	30.0	6777.8
.1	1342.3	.1	1729.7	.1	2161.5	.1	2637.8	31.0	7175.9
.2	1360.6	.2	1750.2	.2	2184.3	.2	2662.8	32.0	7585.2
.3	1379.0	.3	1770.9	.3	2207.2	.3	2687.9	33.0	8005.6
.4	1397.6	.4	1791.6	.4	2230.1	.4	2713.1	34.0	8437.0
.5	1416.2	.5	1812.5	.5	2253.2	.5	2738.4	35.0	8879.6
.6	1435.0	.6	1833.5	.6	2276.4	.6	2763.9	36.0	9333.3
.7	1453.8	.7	1854.6	.7	2299.8	.7	2789.4	37.0	9798.1
.8	1472.8	.8	1875.8	.8	2323.2	18.0	2866.7	38.0	10274.1
.9	1491.9	.9	1897.1	.9	2346.7	19.0	3131.5	39.0	10761.1

TABLE NO. 6.—EXCAVATION AND EMBANKMENT.

CUBIC YARDS.

Prismoids 100 feet long. Slopes 1½ Horizontal to 1 Perpendicular. Breadth of Base 28 feet.

Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards
0.0	0.0	2.0	229.6	4.0	503.7	6.0	822.2	8.0	1185.2
.1	10.4	.1	242.3	.1	518.6	.1	839.3	.1	1204.5
.2	21.0	.2	255.0	.2	533.6	.2	856.5	.2	1223.9
.3	31.6	.3	267.9	.3	548.6	.3	873.8	.3	1243.5
.4	42.4	.4	280.9	.4	563.9	.4	891.3	.4	1263.1
.5	53.2	.5	294.0	.5	579.2	.5	908.8	.5	1282.9
.6	64.2	.6	307.2	.6	594.6	.6	926.4	.6	1302.7
.7	75.3	.7	320.5	.7	610.1	.7	944.2	.7	1322.7
.8	86.5	.8	333.9	.8	625.8	.8	962.1	.8	1342.8
.9	97.8	.9	347.5	.9	641.5	.9	980.1	.9	1363.0
1.0	109.3	3.0	361.1	5.0	657.4	7.0	998.1	9.0	1383.3
.1	120.8	.1	374.9	.1	673.4	.1	1016.4	.1	1403.8
.2	132.4	.2	388.7	.2	689.5	.2	1034.7	.2	1424.3
.3	144.2	.3	402.7	.3	705.7	.3	1053.1	.3	1444.9
.4	156.1	.4	416.8	.4	722.0	.4	1071.6	.4	1465.7
.5	168.1	.5	431.0	.5	738.4	.5	1090.3	.5	1486.6
.6	180.1	.6	445.3	.6	755.0	.6	1109.0	.6	1507.6
.7	192.4	.7	459.8	.7	771.6	.7	1127.9	.7	1528.6
.8	204.7	.8	474.3	.8	788.4	.8	1146.9	.8	1549.9
.9	217.1	.9	488.9	.9	805.2	.9	1166.0	.9	1571.2

TABLE NO. 6—*Continued.*

Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards
10.0	1592.6	12.0	2044.4	14.0	2540.7	16.0	3081.5	20.0	4296.3
.1	1614.1	.1	2068.2	.1	2566.7	.1	3109.7	21.0	4627.8
.2	1635.8	.2	2092.1	.2	2592.8	.2	3138.0	22.0	4970.4
.3	1657.5	.3	2116.1	.3	2619.0	.3	3166.4	23.0	5324.1
.4	1679.4	.4	2140.1	.4	2645.3	.4	3195.0	24.0	5688.9
.5	1701.4	.5	2164.4	.5	2671.8	.5	3223.6	25.0	6064.8
.6	1723.5	.6	2188.7	.6	2698.3	.6	3252.4	26.0	6451.9
.7	1745.7	.7	2213.1	.7	2724.9	.7	3281.2	27.0	6850.0
.8	1768.0	.8	2237.6	.8	2751.7	.8	3310.2	28.0	7259.3
.9	1790.4	.9	2262.3	.9	2778.6	.9	3339.3	29.0	7679.6
11.0	1813.0	13.0	2287.0	15.0	2805.6	17.0	3368.5	30.0	8111.1
.1	1835.6	.1	2311.9	.1	2832.6	.1	3397.8	31.0	8553.7
.2	1858.4	.2	2336.9	.2	2859.9	.2	3427.3	32.0	9007.4
.3	1881.2	.3	2362.0	.3	2887.2	.3	3456.8	33.0	9472.2
.4	1904.2	.4	2387.2	.4	2914.6	.4	3486.4	34.0	9948.1
.5	1927.3	.5	2412.5	.5	2942.1	.5	3516.2	35.0	10435.2
.6	1950.5	.6	2437.9	.6	2969.8	.6	3546.1	36.0	10933.3
.7	1973.8	.7	2463.5	.7	2997.5	.7	3576.1	37.0	11442.6
.8	1997.3	.8	2489.1	.8	3025.4	18.0	3666.7	38.0	11963.0
.9	2020.8	.9	2514.9	.9	3053.4	19.0	3975.9	39.0	12494.4

TABLE NO. 7.—EXCAVATION AND EMBANKMENT.

CUBIC YARDS.

Prismoids 100 feet long. Slopes 1 Horizontal to 1 Perpendicular. Breadth of Base 18 feet.

Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards
0.0	0.0	2.0	148.1	4.0	325.9	6.0	533.3	8.0	770.4
.1	6.7	.1	156.3	.1	335.6	.1	544.5	.1	783.0
.2	13.5	.2	164.6	.2	345.3	.2	555.7	.2	795.7
.3	20.3	.3	172.9	.3	355.1	.3	567.0	.3	808.5
.4	27.3	.4	181.3	.4	365.0	.4	578.4	.4	821.3
.5	34.3	.5	189.8	.5	375.0	.5	589.8	.5	834.3
.6	41.3	.6	198.4	.6	385.0	.6	601.3	.6	847.3
.7	48.5	.7	207.0	.7	395.1	.7	612.9	.7	860.3
.8	55.7	.8	215.7	.8	405.3	.8	624.6	.8	873.5
.9	63.0	.9	224.5	.9	415.6	.9	636.3	.9	886.7
1.0	70.4	3.0	233.3	5.0	425.9	7.0	648.1	9.0	900.0
.1	77.8	.1	242.3	.1	436.3	.1	660.0	.1	913.4
.2	85.3	.2	251.3	.2	446.8	.2	672.0	.2	926.8
.3	92.9	.3	260.3	.3	457.4	.3	684.0	.3	940.3
.4	100.6	.4	269.5	.4	468.0	.4	696.1	.4	953.9
.5	108.3	.5	278.7	.5	478.7	.5	708.3	.5	967.6
.6	116.1	.6	288.0	.6	489.5	.6	720.6	.6	981.3
.7	124.0	.7	297.4	.7	500.3	.7	732.9	.7	995.1
.8	132.0	.8	306.8	.8	511.3	.8	745.3	.8	1009.0
.9	140.0	.9	316.3	.9	522.3	.9	757.8	.9	1023.0

TABLE NO. 7—*Continued.*

Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards
10.0	1037.0	12.0	1333.3	14.0	1659.3	16.0	2014.8	20.0	2814.8
.1	1051.1	.1	1348.9	.1	1676.3	.1	2033.4	21.0	3033.3
.2	1065.3	.2	1364.6	.2	1693.5	.2	2052.0	22.0	3259.3
.3	1079.6	.3	1380.3	.3	1710.7	.3	2070.7	23.0	3492.6
.4	1093.9	.4	1396.1	.4	1728.0	.4	2089.5	24.0	3733.4
.5	1108.3	.5	1412.0	.5	1745.4	.5	2108.3	25.0	3981.5
.6	1122.8	.6	1428.0	.6	1762.8	.6	2127.3	26.0	4237.0
.7	1137.4	.7	1444.0	.7	1780.3	.7	2146.3	27.0	4500.0
.8	1152.0	.8	1460.1	.8	1797.9	.8	2165.3	28.0	4770.4
.9	1166.7	.9	1476.3	.9	1815.6	.9	2184.5	29.0	5048.1
11.0	1181.5	13.0	1492.6	15.0	1833.3	17.0	2203.7	30.0	5333.3
.1	1196.3	.1	1508.9	.1	1851.1	.1	2223.0	31.0	5625.9
.2	1211.3	.2	1525.3	.2	1869.0	.2	2242.4	32.0	5925.9
.3	1226.3	.3	1541.8	.3	1887.0	.3	2261.8	33.0	6233.3
.4	1241.3	.4	1558.4	.4	1905.0	.4	2281.3	34.0	6548.1
.5	1256.5	.5	1575.0	.5	1923.1	.5	2300.9	35.0	6870.4
.6	1271.7	.6	1591.7	.6	1941.3	.6	2320.6	36.0	7200.0
.7	1287.0	.7	1608.5	.7	1959.6	.7	2340.3	37.0	7537.0
.8	1302.4	.8	1625.3	.8	1977.9	18.0	2400.0	38.0	7881.5
.9	1317.8	.9	1642.3	.9	1996.3	19.0	2603.7	39.0	8233.3

TABLE NO. 8.—EXCAVATION AND EMBANKMENT.

CUBIC YARDS.

Prismoids 100 feet long. Slopes 1 Horizontal to 1 Perpendicular. Breadth of Base 20 feet.

Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards
0.0	0.0	2.0	163.0	4.0	355.6	6.0	577.8	8.0	829.6
.1	7.4	.1	171.9	.1	366.0	.1	589.7	.1	843.0
.2	15.0	.2	180.9	.2	376.4	.2	601.6	.2	856.4
.3	22.6	.3	190.0	.3	387.0	.3	613.7	.3	870.0
.4	30.2	.4	199.1	.4	397.6	.4	625.8	.4	883.6
.5	38.0	.5	208.3	.5	408.3	.5	638.0	.5	897.2
.6	45.8	.6	217.6	.6	419.1	.6	650.2	.6	911.0
.7	53.7	.7	227.0	.7	430.0	.7	662.6	.7	924.8
.8	61.6	.8	236.4	.8	440.9	.8	675.0	.8	938.7
.9	69.7	.9	246.0	.9	451.9	.9	687.4	.9	952.6
1.0	77.8	3.0	255.6	5.0	463.0	7.0	700.0	9.0	966.7
.1	86.0	.1	265.2	.1	474.1	.1	712.6	.1	980.8
.2	94.2	.2	275.0	.2	485.3	.2	725.3	.2	995.0
.3	102.6	.3	284.8	.3	496.6	.3	738.1	.3	1009.2
.4	111.0	.4	294.7	.4	508.0	.4	751.0	.4	1023.6
.5	119.4	.5	304.6	.5	519.4	.5	763.9	.5	1038.0
.6	128.0	.6	314.7	.6	531.0	.6	776.9	.6	1052.4
.7	136.6	.7	324.8	.7	542.6	.7	790.0	.7	1067.0
.8	145.3	.8	335.0	.8	554.2	.8	803.1	.8	1081.6
.9	154.1	.9	345.2	.9	566.0	.9	816.3	.9	1096.3

TABLE NO. 8—*Continued.*

Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards
10.0	1111.1	12.0	1422.2	14.0	1763.0	16.0	2133.3	20.0	2963.0
.1	1126.0	.1	1438.6	.1	1780.8	.1	2152.6	21.0	3188.9
.2	1140.9	.2	1455.0	.2	1798.7	.2	2172.0	22.0	3422.2
.3	1155.9	.3	1471.4	.3	1816.6	.3	2191.4	23.0	3663.0
.4	1171.0	.4	1488.0	.4	1834.7	.4	2211.0	24.0	3911.1
.5	1186.1	.5	1504.6	.5	1852.8	.5	2230.6	25.0	4166.7
.6	1201.3	.6	1521.3	.6	1871.0	.6	2250.2	26.0	4429.6
.7	1216.6	.7	1538.1	.7	1889.2	.7	2270.0	27.0	4700.0
.8	1232.0	.8	1555.0	.8	1907.6	.8	2289.8	28.0	4977.8
.9	1247.4	.9	1571.9	.9	1926.0	.9	2309.7	29.0	5263.0
11.0	1263.0	13.0	1588.9	15.0	1944.4	17.0	2329.6	30.0	5555.6
.1	1278.6	.1	1606.0	.1	1963.0	.1	2349.7	31.0	5855.6
.2	1294.2	.2	1623.1	.2	1981.6	.2	2369.8	32.0	6163.0
.3	1310.0	.3	1640.3	.3	2000.3	.3	2390.0	33.0	6477.8
.4	1325.8	.4	1657.6	.4	2019.1	.4	2410.2	34.0	6800.0
.5	1341.7	.5	1675.0	.5	2038.0	.5	2430.6	35.0	7129.6
.6	1357.6	.6	1692.4	.6	2056.9	.6	2451.0	36.0	7466.7
.7	1373.7	.7	1710.0	.7	2075.9	.7	2471.4	37.0	7811.1
.8	1389.8	.8	1727.6	.8	2095.0	18.0	2533.3	38.0	8163.0
.9	1406.0	.9	1745.2	.9	2114.1	19.0	2744.4	39.0	8522.2

TABLE NO. 9.—EXCAVATION AND EMBANKMENT.

CUBIC YARDS.

Prismoids 100 feet long. Slopes 1 Horizontal to 1 Perpendicular. Breadth of Base 22 feet.

Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards
0.0	0.0	2.0	177.8	4.0	385.2	6.0	622.2	8.0	888.9
.1	8.2	.1	187.4	.1	396.3	.1	634.9	.1	903.0
.2	16.4	.2	197.2	.2	407.6	.2	647.6	.2	917.2
.3	24.8	.3	207.0	.3	418.9	.3	660.3	.3	931.4
.4	33.2	.4	216.9	.4	430.2	.4	673.2	.4	945.8
.5	41.7	.5	226.9	.5	441.7	.5	686.1	.5	960.2
.6	50.2	.6	236.9	.6	453.2	.6	699.1	.6	974.7
.7	58.9	.7	247.0	.7	464.8	.7	712.2	.7	989.2
.8	67.6	.8	257.2	.8	476.4	.8	725.3	.8	1003.9
.9	76.3	.9	267.4	.9	488.2	.9	738.6	.9	1018.6
1.0	85.2	3.0	277.8	5.0	500.0	7.0	751.9	9.0	1033.3
.1	94.1	.1	288.2	.1	511.9	.1	765.2	.1	1048.2
.2	103.1	.2	298.7	.2	523.9	.2	778.7	.2	1063.1
.3	112.2	.3	309.2	.3	535.9	.3	792.2	.3	1078.1
.4	121.3	.4	319.9	.4	548.0	.4	805.8	.4	1093.2
.5	130.6	.5	330.6	.5	560.2	.5	819.4	.5	1108.3
.6	139.9	.6	341.3	.6	572.4	.6	833.2	.6	1123.6
.7	149.2	.7	352.2	.7	584.8	.7	847.0	.7	1138.9
.8	158.7	.8	363.1	.8	597.2	.8	860.9	.8	1154.2
.9	168.2	.9	374.1	.9	609.7	.9	874.9	.9	1169.7

TABLE NO. 9—*Continued.*

Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards
10.0	1185.2	12.0	1511.1	14.0	1866.7	16.0	2251.9	20.0	3111.1
.1	1200.8	.1	1528.2	.1	1885.2	.1	2271.9	21.0	3344.4
.2	1216.4	.2	1545.3	.2	1903.9	.2	2292.0	22.0	3585.2
.3	1232.2	.3	1562.6	.3	1922.6	.3	2312.2	23.0	3833.3
.4	1248.0	.4	1579.9	.4	1941.3	.4	2332.4	24.0	4088.9
.5	1263.9	.5	1597.2	.5	1960.2	.5	2352.8	25.0	4351.9
.6	1279.9	.6	1614.7	.6	1979.1	.6	2373.2	26.0	4622.2
.7	1295.9	.7	1632.2	.7	1998.1	.7	2393.7	27.0	4900.0
.8	1312.0	.8	1649.8	.8	2017.2	.8	2414.2	28.0	5185.2
.9	1328.2	.9	1667.4	.9	2036.3	.9	2434.9	29.0	5477.8
11.0	1344.4	13.0	1685.2	15.0	2055.6	17.0	2455.6	30.0	5777.8
.1	1360.8	.1	1703.0	.1	2074.9	.1	2476.3	31.0	6085.2
.2	1377.2	.2	1720.9	.2	2094.2	.2	2497.2	32.0	6400.0
.3	1393.7	.3	1738.9	.3	2113.7	.3	2518.1	33.0	6722.2
.4	1410.2	.4	1756.8	.4	2133.2	.4	2539.1	34.0	7051.9
.5	1426.9	.5	1775.0	.5	2152.8	.5	2560.2	35.0	7388.9
.6	1443.6	.6	1793.2	.6	2172.4	.6	2581.3	36.0	7733.3
.7	1460.3	.7	1811.4	.7	2192.2	.7	2602.6	37.0	8085.2
.8	1477.2	.8	1829.8	.8	2212.0	18.0	2666.7	38.0	8444.4
.9	1494.1	.9	1848.2	.9	2231.9	19.0	2885.2	39.0	8811.1

TABLE NO. 10.—EXCAVATION AND EMBANKMENT.

CUBIC YARDS.

Prismoids 100 feet long. Slopes 1 Horizontal to 1 Perpendicular Breadth of Base 24 feet.

Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards
0.0	0.0	2.0	192.6	4.0	414.8	6.0	666.7	8.0	948.1
.1	8.9	.1	203.0	.1	426.7	.1	680.0	.1	963.0
.2	17.9	.2	213.5	.2	438.7	.2	693.5	.2	977.9
.3	27.0	.3	224.0	.3	450.7	.3	707.0	.3	992.9
.4	36.1	.4	234.7	.4	462.8	.4	720.6	.4	1008.0
.5	45.4	.5	245.4	.5	475.0	.5	734.3	.5	1023.1
.6	54.7	.6	256.1	.6	487.3	.6	748.0	.6	1038.4
.7	64.0	.7	267.0	.7	499.6	.7	761.8	.7	1053.7
.8	73.5	.8	277.9	.8	512.0	.8	775.7	.8	1069.0
.9	83.0	.9	288.9	.9	524.5	.9	789.7	.9	1084.5
1.0	92.6	3.0	300.0	5.0	537.0	7.0	803.7	9.0	1100.0
.1	102.3	.1	311.1	.1	549.7	.1	817.8	.1	1115.6
.2	112.0	.2	322.4	.2	562.4	.2	832.0	.2	1131.3
.3	121.8	.3	333.7	.3	575.1	.3	846.3	.3	1147.0
.4	131.7	.4	345.0	.4	588.0	.4	860.6	.4	1162.8
.5	141.7	.5	356.5	.5	600.9	.5	875.0	.5	1178.7
.6	151.7	.6	368.0	.6	613.9	.6	889.5	.6	1194.7
.7	161.8	.7	379.6	.7	627.0	.7	904.0	.7	1210.7
.8	172.0	.8	391.3	.8	640.1	.8	918.7	.8	1226.8
.9	182.3	.9	403.0	.9	653.4	.9	933.4	.9	1243.0

TABLE NO. 10—*Continued.*

Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards
10.0	1259.3	12.0	1600.0	14.0	1970.4	16.0	2370.4	20.0	3259.3
.1	1275.6	.1	1617.8	.1	1989.7	.1	2391.1	21.0	3500.0
.2	1292.0	.2	1635.7	.2	2009.0	.2	2412.0	22.0	3748.1
.3	1308.5	.3	1653.7	.3	2028.5	.3	2432.9	23.0	4003.7
.4	1325.0	.4	1671.7	.4	2048.0	.4	2453.9	24.0	4266.7
.5	1341.7	.5	1689.8	.5	2067.6	.5	2475.0	25.0	4537.0
.6	1358.4	.6	1708.0	.6	2087.3	.6	2496.1	26.0	4814.8
.7	1375.1	.7	1726.3	.7	2107.0	.7	2517.4	27.0	5100.0
.8	1392.0	.8	1744.6	.8	2126.8	.8	2538.7	28.0	5392.6
.9	1408.9	.9	1763.0	.9	2146.7	.9	2560.0	29.0	5692.6
11.0	1425.9	13.0	1781.5	15.0	2166.7	17.0	2581.5	30.0	6000.0
.1	1443.0	.1	1800.0	.1	2186.7	.1	2603.0	31.0	6314.8
.2	1460.1	.2	1818.7	.2	2206.8	.2	2624.6	32.0	6637.0
.3	1477.4	.3	1837.4	.3	2227.0	.3	2646.3	33.0	6966.7
.4	1494.7	.4	1856.1	.4	2247.3	.4	2668.0	34.0	7303.7
.5	1512.0	.5	1875.0	.5	2267.6	.5	2689.8	35.0	7648.1
.6	1529.5	.6	1893.9	.6	2288.0	.6	2711.7	36.0	8000.0
.7	1547.0	.7	1912.9	.7	2308.5	.7	2733.7	37.0	8359.3
.8	1564.6	.8	1932.0	.8	2329.0	18.0	2800.0	38.0	8725.9
.9	1582.3	.9	1951.1	.9	2349.7	19.0	3025.9	39.0	9100.0

TABLE NO. 11.—EXCAVATION AND EMBANKMENT.

CUBIC YARDS.

Prismoids 100 feet long. Slopes ½ Horizontal to 1 Perpendicular. Breadth of Base 20 feet.

Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards
0.0	0.0	2.0	155.6	4.0	325.9	6.0	511.1	8.0	711.1
.1	7.4	.1	163.7	.1	334.8	.1	520.8	.1	721.5
.2	14.9	.2	171.9	.2	343.8	.2	530.4	.2	731.9
.3	22.4	.3	180.2	.3	352.8	.3	540.2	.3	742.4
.4	29.9	.4	188.4	.4	361.8	.4	549.9	.4	752.9
.5	37.5	.5	196.8	.5	370.8	.5	559.7	.5	763.4
.6	45.1	.6	205.1	.6	379.9	.6	569.6	.6	774.0
.7	52.8	.7	213.5	.7	389.1	.7	579.4	.7	784.6
.8	60.4	.8	221.9	.8	398.2	.8	589.3	.8	795.3
.9	68.2	.9	230.4	.9	407.4	.9	599.3	.9	805.9
1.0	75.9	3.0	238.9	5.0	416.7	7.0	609.3	9.0	816.7
.1	83.7	.1	247.4	.1	425.9	.1	619.3	.1	827.4
.2	91.6	.2	256.0	.2	435.3	.2	629.3	.2	838.2
.3	99.4	.3	264.6	.3	444.6	.3	639.4	.3	849.1
.4	107.3	.4	273.3	.4	454.0	.4	649.6	.4	859.9
.5	115.3	.5	281.9	.5	463.4	.5	659.7	.5	870.8
.6	123.3	.6	290.7	.6	472.9	.6	669.9	.6	881.8
.7	131.3	.7	299.4	.7	482.4	.7	680.2	.7	892.8
.8	139.3	.8	308.2	.8	491.9	.8	690.4	.8	903.8
.9	147.4	.9	317.1	.9	501.5	.9	700.8	.9	914.8

TABLE NO. 11—*Continued.*

Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards
10.0	925.9	12.0	1155.6	14.0	1400.0	16.0	1659.3	20.0	2222.2
.1	937.1	.1	1167.4	.1	1412.6	.1	1672.6	21.0	2372.2
.2	948.2	.2	1179.3	.2	1425.3	.2	1686.0	22.0	2525.9
.3	959.4	.3	1191.3	.3	1437.9	.3	1699.4	23.0	2683.3
.4	970.7	.4	1203.3	.4	1450.7	.4	1712.9	24.0	2844.4
.5	981.9	.5	1215.3	.5	1463.4	.5	1726.4	25.0	3009.3
.6	993.3	.6	1227.3	.6	1476.2	.6	1739.9	26.0	3177.8
.7	1004.6	.7	1239.4	.7	1489.1	.7	1753.5	27.0	3350.0
.8	1016.0	.8	1251.6	.8	1501.9	.8	1767.1	28.0	3525.9
.9	1027.4	.9	1263.7	.9	1514.8	.9	1780.8	29.0	3705.6
11.0	1038.9	13.0	1275.9	15.0	1527.8	17.0	1794.4	30.0	3888.9
.1	1050.4	.1	1288.2	.1	1540.8	.1	1808.2	31.0	4075.9
.2	1061.9	.2	1300.4	.2	1553.8	.2	1821.9	32.0	4266.7
.3	1073.5	.3	1312.8	.3	1566.8	.3	1835.7	33.0	4461.1
.4	1085.1	.4	1325.1	.4	1579.9	.4	1849.6	34.0	4659.3
.5	1096.8	.5	1337.5	.5	1593.1	.5	1863.4	35.0	4861.1
.6	1108.4	.6	1349.9	.6	1606.2	.6	1877.3	36.0	5066.7
.7	1120.2	.7	1362.4	.7	1619.4	.7	1891.3	37.0	5275.9
.8	1131.9	.8	1374.9	.8	1632.7	18.0	1933.3	38.0	5488.9
.9	1143.7	.9	1387.4	.9	1645.9	19.0	2075.9	39.0	5705.6

TABLE NO. 12.—EXCAVATION AND EMBANKMENT.

CUBIC YARDS.

Prismoids 100 feet long. Slopes ¼ Horizontal to 1 Perpendicular. Breadth of Base 18 feet.

Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards
0.0	0.0	2.0	137.0	4.0	281.5	6.0	433.3	8.0	592.6
.1	6.7	.1	144.1	.1	288.9	.1	441.1	.1	600.8
.2	13.4	.2	151.1	.2	296.3	.2	448.9	.2	608.9
.3	20.1	.3	158.2	.3	303.8	.3	456.8	.3	617.1
.4	26.8	.4	165.3	.4	311.3	.4	464.6	.4	625.3
.5	33.6	.5	172.5	.5	318.8	.5	472.5	.5	633.6
.6	40.3	.6	179.6	.6	326.3	.6	480.3	.6	641.8
.7	47.1	.7	186.8	.7	333.8	.7	488.2	.7	650.1
.8	53.9	.8	193.9	.8	341.3	.8	496.1	.8	658.4
.9	60.8	.9	201.1	.9	348.9	.9	504.1	.9	666.7
1.0	67.6	3.0	208.3	5.0	356.5	7.0	512.0	9.0	675.0
.1	74.5	.1	215.6	.1	364.1	.1	520.0	.1	683.3
.2	81.3	.2	222.8	.2	371.7	.2	528.0	.2	691.7
.3	88.2	.3	230.1	.3	379.3	.3	536.0	.3	700.1
.4	95.1	.4	237.4	.4	387.0	.4	544.0	.4	708.5
.5	102.1	.5	244.7	.5	394.7	.5	552.1	.5	716.9
.6	109.0	.6	252.0	.6	402.4	.6	560.1	.6	725.3
.7	116.0	.7	259.3	.7	410.1	.7	568.2	.7	733.8
.8	123.0	.8	266.7	.8	417.8	.8	576.3	.8	742.3
.9	130.0	.9	274.1	.9	425.6	.9	584.5	.9	750.8

TABLE NO. 12—*Continued.*

Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards
10.0	759.3	12.0	933.3	14.0	1114.8	16.0	1303.7	20.0	1703.7
.1	767.8	.1	942.2	.1	1124.1	.1	1313.3	21.0	1808.3
.2	776.3	.2	951.1	.2	1133.4	.2	1323.0	22.0	1914.8
.3	784.9	.3	960.1	.3	1142.7	.3	1332.7	23.0	2023.1
.4	793.5	.4	969.0	.4	1152.0	.4	1342.4	24.0	2133.3
.5	802.1	.5	978.0	.5	1161.3	.5	1352.1	25.0	2245.4
.6	810.7	.6	987.0	.6	1170.7	.6	1361.8	26.0	2359.3
.7	819.3	.7	996.0	.7	1180.1	.7	1371.6	27.0	2475.0
.8	828.0	.8	1005.0	.8	1189.5	.8	1381.3	28.0	2592.6
.9	836.7	.9	1014.1	.9	1198.9	.9	1391.1	29.0	2712.0
11.0	845.4	13.0	1023.1	15.0	1208.3	17.0	1400.9	30.0	2833.3
.1	854.1	.1	1032.2	.1	1217.8	.1	1410.8	31.0	2956.5
.2	862.8	.2	1041.3	.2	1227.3	.2	1420.6	32.0	3081.5
.3	871.6	.3	1050.5	.3	1236.8	.3	1430.5	33.0	3208.3
.4	880.3	.4	1059.6	.4	1246.3	.4	1440.3	34.0	3337.0
.5	889.1	.5	1068.8	.5	1255.8	.5	1450.2	35.0	3467.6
.6	897.9	.6	1077.9	.6	1265.3	.6	1460.1	36.0	3600.0
.7	906.8	.7	1087.1	.7	1274.9	.7	1470.1	37.0	3734.3
.8	915.6	.8	1096.3	.8	1284.5	18.0	1500.0	38.0	3870.4
.9	924.5	.9	1105.6	.9	1294.1	19.0	1600.9	39.0	4008.3

TABLE NO. 13.—EXCAVATION AND EMBANKMENT.

CUBIC YARDS.

Prismoids 100 feet long. Slopes ½ Horizontal to 1 Perpendicular. Breadth of Base 20 feet.

Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards
0.0	0.0	2.0	151.9	4.0	311.1	6.0	477.8	8.0	651.9
.1	7.4	.1	159.6	.1	319.3	.1	486.3	.1	660.8
.2	14.9	.2	167.4	.2	327.4	.2	494.9	.2	669.7
.3	22.3	.3	175.3	.3	335.6	.3	503.4	.3	678.6
.4	29.8	.4	183.1	.4	343.9	.4	512.0	.4	687.6
.5	37.3	.5	191.0	.5	352.1	.5	520.6	.5	696.5
.6	44.8	.6	198.9	.6	360.3	.6	529.2	.6	705.5
.7	52.3	.7	206.8	.7	368.6	.7	537.9	.7	714.5
.8	59.9	.8	214.7	.8	376.9	.8	546.5	.8	723.6
.9	67.4	.9	222.6	.9	385.2	.9	555.2	.9	732.6
1.0	75.0	3.0	230.6	5.0	393.5	7.0	563.9	9.0	741.7
.1	82.6	.1	238.5	.1	401.9	.1	572.6	.1	750.8
.2	90.2	.2	246.5	.2	410.2	.2	581.3	.2	759.9
.3	97.9	.3	254.5	.3	418.6	.3	590.1	.3	769.0
.4	105.5	.4	262.6	.4	427.0	.4	598.9	.4	778.1
.5	113.2	.5	270.6	.5	435.4	.5	607.6	.5	787.3
.6	120.9	.6	278.7	.6	443.9	.6	616.4	.6	796.4
.7	128.6	.7	286.8	.7	452.3	.7	625.3	.7	805.6
.8	136.3	.8	294.9	.8	460.8	.8	634.1	.8	814.9
.9	144.1	.9	303.0	.9	469.3	.9	643.0	.9	824.1

TABLE NO. 13—*Continued.*

Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards	Height	Cubic Yards
10.0	833.3	12.0	1022.2	14.0	1218.5	16.0	1422.2	20.0	1851.9
.1	842.6	.1	1031.9	.1	1228.5	.1	1432.6	21.0	1963.9
.2	851.9	.2	1041.5	.2	1238.6	.2	1443.0	22.0	2077.8
.3	861.2	.3	1051.2	.3	1248.6	.3	1453.4	23.0	2193.5
.4	870.5	.4	1060.9	.4	1258.7	.4	1463.9	24.0	2311.1
.5	879.9	.5	1070.6	.5	1268.8	.5	1474.3	25.0	2430.6
.6	889.2	.6	1080.3	.6	1278.9	.6	1484.8	26.0	2551.9
.7	898.6	.7	1090.1	.7	1289.0	.7	1495.3	27.0	2675.0
.8	908.0	.8	1099.9	.8	1299.1	.8	1505.8	28.0	2800.0
.9	917.4	.9	1109.6	.9	1309.3	.9	1516.3	29.0	2926.9
11.0	926.9	13.0	1119.4	15.0	1319.4	17.0	1526.9	30.0	3055.6
.1	936.3	.1	1129.3	.1	1329.6	.1	1537.4	31.0	3186.1
.2	945.8	.2	1139.1	.2	1339.9	.2	1548.0	32.0	3318.5
.3	955.3	.3	1149.0	.3	1350.1	.3	1558.6	33.0	3452.8
.4	964.8	.4	1158.9	.4	1360.3	.4	1569.2	34.0	3588.9
.5	974.3	.5	1168.8	.5	1370.6	.5	1579.9	35.0	3726.9
.6	983.9	.6	1178.7	.6	1380.9	.6	1590.5	36.0	3866.7
.7	993.4	.7	1188.6	.7	1391.2	.7	1601.2	37.0	4008.3
.8	1003.0	.8	1198.6	.8	1401.5	18.0	1633.3	38.0	4151.9
.9	1012.6	.9	1208.5	.9	1411.9	19.0	1741.7	39.0	4297.2

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